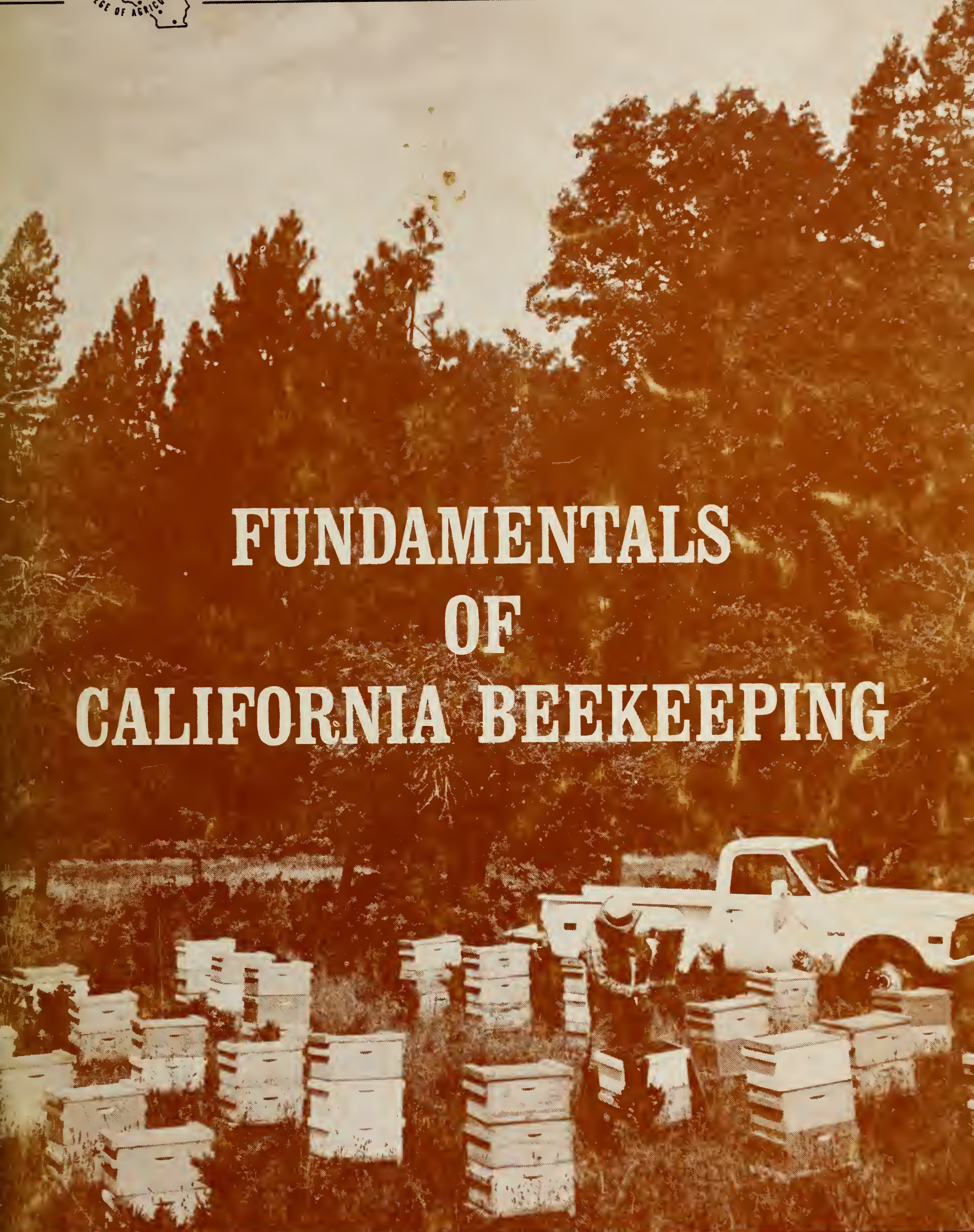
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

FUNDAMENTALS OF CALIFORNIA BEEKEEPING



CALIFORNIA AGRICULTURAL
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FUNDAMENTALS OF CALIFORNIA BEEKEEPING

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DECEMBER, 1971

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BEEKEEPING IN CALIFORNIA

A primitive drawing dating from 7000 B.C. found on a cave wall in eastern Spain is the first known evidence that early man robbed honey from bees. Honey's importance as a food and as a medicine has been realized throughout recorded history. The honey bee (*Apis mellifera* L.) was first brought to North America by English settlers about 1622. In his *Notes on the State of Virginia,* Thomas Jefferson observed that American Indians called the honey bee, "The white man's fly." California saw its first successful introduction of honey bees early in 1853 when the botanist Christopher A. Shelton established an apiary of twelve colonies just north of San Jose. Only one survived, but it cast three swarms that summer and by 1858 there were at least 150 colonies directly descended from the Shelton hive.

John S. Harbison, California's first professional beekeeper, imported 57 colonies from Pennsylvania to Sacramento in December, 1857, and of these 50 survived. He increased them by artificial division to 136 hives, of which he sold 130 for $100 each. Harbison then imported 114 more colonies with a loss of only eleven, and in 1859 he sold nearly $30,000 worth of bees, keeping 138 colonies himself for the next season. Harbison's sensational success started a "bee rush" to California and in 1859 and 1860 more than 8,000 colonies of bees were imported from the east coast via the Isthmus of Panama. This was the largest long-distance shipment of honey bees ever made up to that time. Another bee rush began in 1869 when Harbison moved his bees from Sacramento to the newly discovered sage and wild buckwheat ranges of San Diego county. San Diego county produced more honey than any other county in the state in 1873; by 1876, Harbison had a total of 3,750 colonies of bees in twelve apiaries and was recognized as the largest honey producer in the world. Since that time, California has been the nation's principal honey-producing state.

Twentieth century beekeeping has its own unique problems, most of them arising from greatly increased urbanization and the consequent fact that nectar sources are widely scattered. Fortunately, however, small numbers of colonies can sometimes do well in or near cities because of the diversity of flowering plants within flight range of the bees. The amateur beekeeper may often profit from this fact.

Importance of beekeeping to California agriculture

Beekeeping in California is an integral part of California agriculture because it is highly important in the pollination of vegetable, fruit, and nut crops, and vegetable and forage seed crops. The total annual value of all crops pollinated is approximately $300,000,000. The annual gross income to beekeepers from pollination services, packaged and queen bee production, and sale of honey and beeswax is about $7,000,000. Total production of honey in California averages 25,000,000 pounds yearly.

California's climate makes commercial beekeeping a migratory industry. It usually does not rain in most of the state from June through August, so uncultivated nectar and pollen plants bloom at various times, depending on the amount of rainfall in winter and early spring and on the soil's ability to hold water. These factors vary greatly over the state, and therefore bees must be moved to the best pasture each year to produce a maximum honey crop. Additionally, honey bees are

moved to approximately 25 different types of crops throughout the state that require pollination; California ranks first nationally in the production of 15 of these crops. An apiary (see "Glossary," page 52) may be moved three to five times or more annually by commercial beekeepers, and even part-time beekeepers sometimes move their bees. In irrigated regions and in many mountain locations, the amateur non-migratory beekeeper can often find nectar sources that will provide enough food for his bees and a surplus of honey.

Keeping bees for pleasure or profit

Beekeeping has many attractions—among them are the production of honey for home use and the extra income derived from surplus honey. For those interested in botany, beekeeping provides an excellent opportunity for studying bee-pasture plants and the relationship of honey bees to flowers when bees are collecting pollen and nectar and when they are acting as pollinators.

Beekeeping offers many income-producing opportunities, either as a hobby, as a part-time occupation, or as a full-time commercial enterprise. The hobbyist may have a few colonies, but the part-time beekeeper may have as many as 500. (A commercial beekeeper is defined by the California State Department of Agriculture as one who has 640 or more colonies.) Two thousand colonies are the upper limit for a one-man commercial operation. In larger operations, one man may function not only as manager of his own colonies but also as contractor and manager for other professional beekeepers as providing pollination service.

Because of increased orchard plantings in California there is a growing demand for bees for pollination. An example is the continual annual increase in acreage planted to almonds which is creating a shortage of bees for almond pollination. On this basis alone it is reasonable to predict a greater need for bees and beekeepers in the years ahead.

HOW TO BECOME A BEEKEEPER

Begin by talking to a beekeeper who has been in your area for several years and who has local beekeeping experience—with his advice you can better decide whether you want to keep bees. If you can work with him before you get your own bees, you will learn many valuable skills. To locate beekeepers in your county ask the Agricultural Commissioner or Farm Advisor.

If you are going to keep bees:

- Check local laws regarding keeping bees.
- Determine your reaction to bee stings —your doctor can test this.
- Use only standard equipment.
- Locate your apiary close to home, away from pedestrian and auto traffic, and in an area where the bees will not disturb people or livestock.
- Supply the apiary with its own water source.
- Make certain bees have adequate food to sustain them until nectar flow.
- Protect bottom of hives from wet ground and termites.
- Do not locate where bees can collect pollen from California buckeye blossoms, as its pollen is toxic to them.

What kind of bees are best? The Caucasian and Italian races of bees are most popular. Of these, the Italian is found in most apiaries.

Italian bees have three to five yellow bands on the abdomen. The five-yellow-banded Italians are often called golden Italians, and the darker or three-yellow-banded bees are called leather-colored Italians. Italian bees winter well and are good producers.

Caucasians are black with a grayish pubescence which gives an over-all gray appearance. They usually are considered gentler than Italians. Caucasians do not swarm frequently, but they do build more burr comb and bridge with wax between combs.

Bees can be obtained by:

- buying a colony in a hive
- purchasing them in packages
- hiving a swarm

Buying colonies in hives. This is the easiest way to get started. With bees already in the hive it is not necessary to hive them, as must be done when packaged bees or swarms are used. *The colony should be inspected by the county bee inspector to be sure it is free of disease.*

Buying and installing packaged bees. Packaged bees with queen can be purchased from a beekeeper or from a bee-supply company. Such packages contain the queen in a separate cage inside the package itself. Order the bees early enough for them to arrive in spring 8 to 12 weeks before the principal nectar-producing plants bloom in your neighborhood—this gives the bees time to build a colony population large enough to take full advantage of the nectar and pollen when it becomes available.

When the packaged bees arrive, a syrup made of equal parts of water and sugar should be sprayed or shaken onto the bees through the wire sides of the package, giving them all that they will take but not so much that they become stuck together in a mass. The bees can be installed immediately into the waiting hive if it is a cool and cloudy day. If it is not, put them into a cool room until just before dark and then—after spraying them with syrup again—install them in the hive. The queen is introduced into the hive immediately after the workers are installed. Her cage must be lightly sprayed with sugar syrup, then its cover is removed so she can move in with the workers.

Hiving a swarm. Hiving a swarm (catching bees and putting them in hives) is difficult for a beginner, so it is best to get the help of an experienced beekeeper. However, this may be the cheapest way to get started in beekeeping, as swarms can usually be obtained by contacting the agricultural commissioner, fire department, police department, sheriff, farm advisor, or animal control center.

After bees are hived from packages or swarms, do not disturb them for several days. The queen will lay eggs in a week or less and the colony will start its work. Abundant pollen is necessary for the colony to use as food for rearing the brood (eggs, larvae and capped cells containing pupae), and this should be supplied from flowers growing nearby. If nectar and pollen are not available in the field, it may be necessary to feed the bees (see pages 13 and 15.

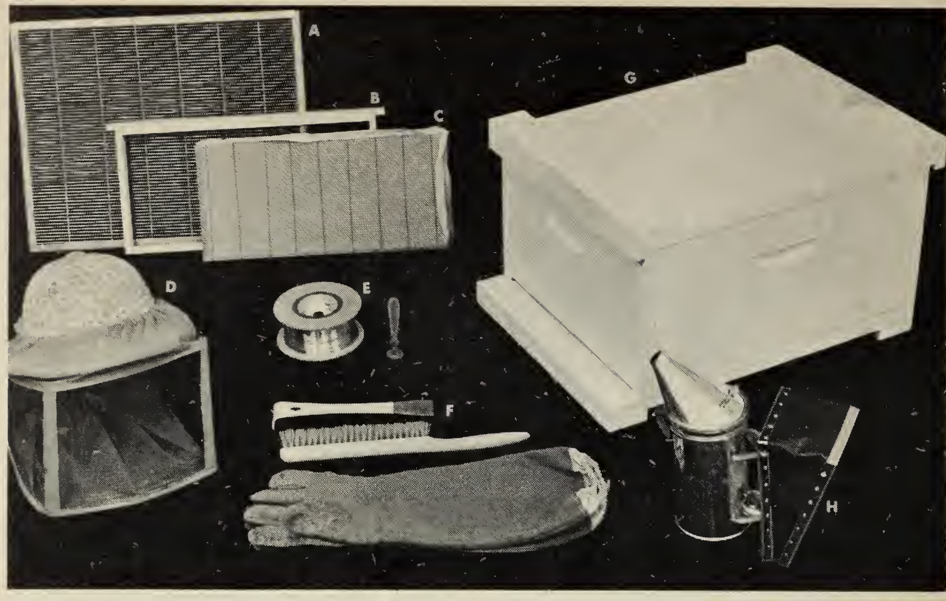
BEEKEEPING EQUIPMENT

These items are needed to keep bees:

- One 2-story 8- or 10-frame hive
- Smoker
- Hive tool
- Queen excluder (optional)
- Gloves (optional)
- White coveralls (optional)
- Veil and hat
- Spur or electric embedder
- Spool of #26 wire
- Frame wiring jig
- Frame nailing jig
- Additional supers, frames, and wax foundation

The hive: supers and frames

Use only standard hive equipment so that all parts will fit together: A 2-story, 8- or 10-frame hive will be needed. Supers (see "Glossary," page 52, for terms used in beekeeping) placed on the hive body may be "full depth" (9⅝ inches deep), "three-quarter" (6⅝ inches deep), "shallow" (5¾ inches deep), or "comb honey" (4⅝ inches deep). The type of super used depends on whether the beekeeper desires a smaller super to reduce the weight of the units he may have to lift, or on the type of honey he wishes to produce. A



Equipment for beginning beekeeping. **Upper left, left to right:** (A) wire-grid queen excluder; (B) hive frame; (C) sheet of beeswax foundation with vertical wires for support. **Lower left:** (D) hat and wire veil; (E) spool of wire for wiring frames, and spur embedder. **In front of spool:** (F) hive tool, bee brush, gloves. **Upper right:** (G) 1-story 10-frame hive. **Lower right:** (H) smoker, with bellows. All these items are available commercially.

single full-depth super is usually used to begin a colony; later, when the queen needs more space for laying eggs, another full-depth super can be placed on top of the hive body.

Each hive body and super should have 8 or 10 frames and each frame should have a sheet of wax foundation to support the beeswax comb the bees will build later. Commercial foundation comes in three weights:

Heavy brood and medium brood. Brood foundation is used in frames where the queen may lay eggs. Medium brood foundation will be suitable for the beginning beekeeper. Heavy brood is best when frames receive much handling.

Thin. Thin foundation is used only for production of comb honey.

Because the weight of brood, pollen, and honey stored in combs can cause the combs to sag (sagged combs enlarge the honey cells, and such cells produce only drone bees), additional support for the combs is needed. This is provided by cross-wiring frames, as described on page 6.

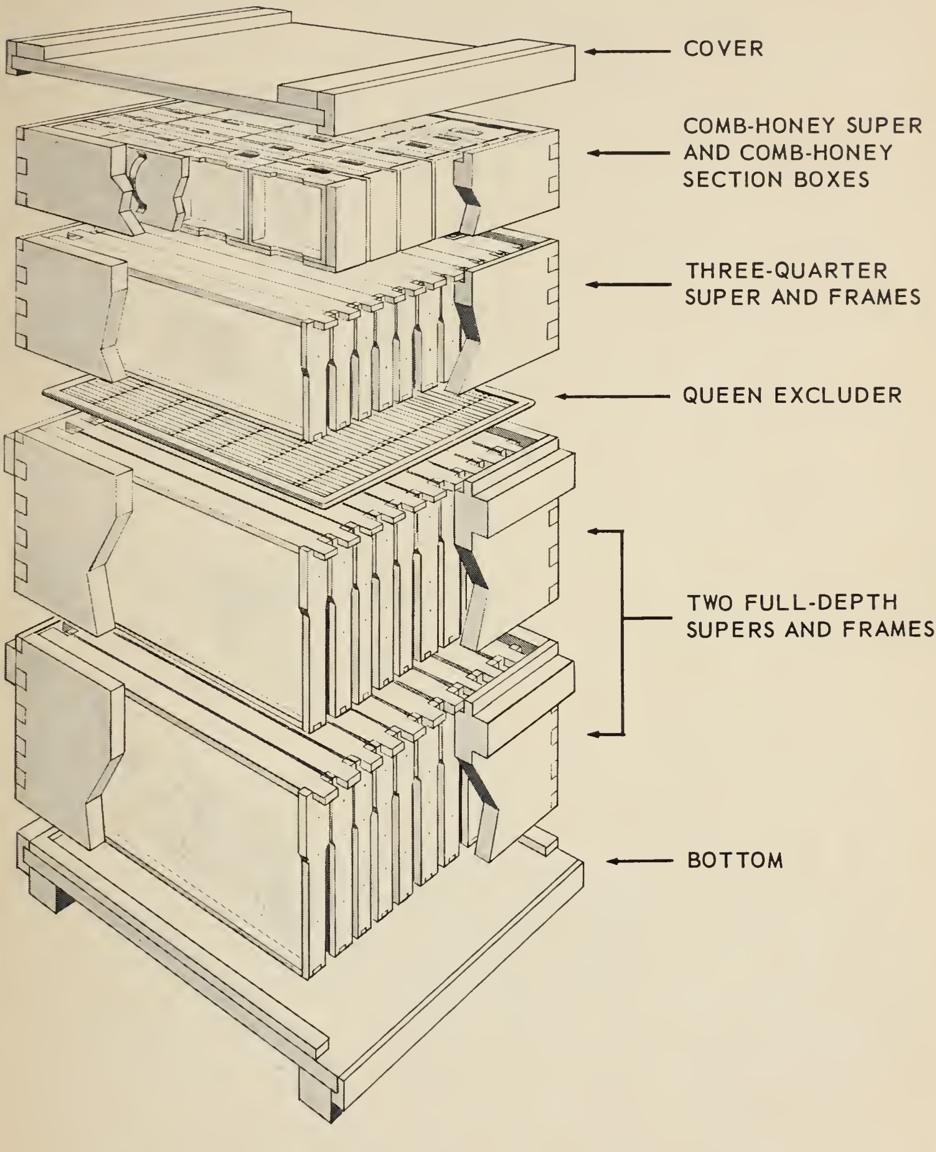
Either one of two types of frames may be used, and the choice is largely one of personal option. The types are:

Groove-top-bar with solid or split bottom bar. These are easiest to prepare for installation when they are used with foundation whose ends are metal-bound, or with foundation bound on all four sides and vertically wired. If foundation without bound ends is used, one end of the foundation must be waxed into the top-bar groove (top bar shown on photo bottom page 7). If the bottom bar is solid, the frame itself must be cross wired to secure the other end of the foundation; if the bottom bar is split, the other end of the foundation may simply be tacked into the split. This type of frame is the more expensive of the two types used.

Wedge-top frames with solid or split bottom bar. These have a wooden strip which is nailed into place to hold foun-

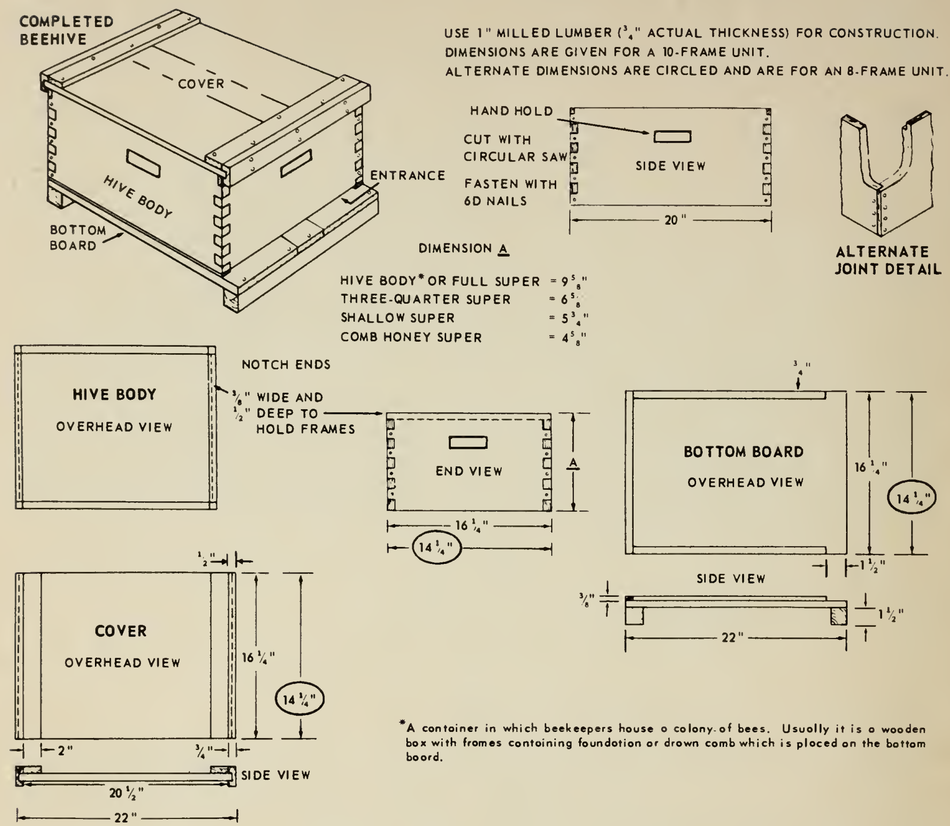
BEE HIVE - OPTIONAL PARTS

Component Parts, Depending on Management



Bee hive detail, showing optional parts used in different types of bee management.

BEEHIVE CONSTRUCTION



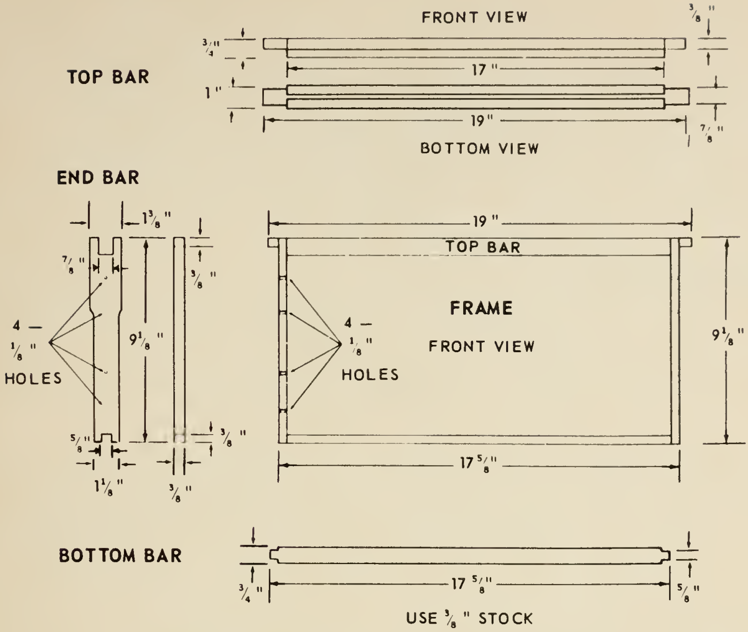
Beehive—California plan.

dation in the frame. With this type, it is necessary to cross wire the frame unless the foundation to be used has a plastic base, or is vertically wired, or has metal-bound ends.

Cross wiring frames for installation of foundation. The photo on bottom of next page shows a jig for cross wiring. The frame in the jig is cross wired by threading #26 tinned wire through holes in the end bars, beginning at the end bar near the wire roll; the wire is laced through holes in the end bars, back and forth, ending at the top right of the frame shown in the photograph. When the wire is pulled through this last hole, it is wound around a wire tack on the edge of the end bar; the tack is then driven down into the wood. To tighten wire in the jig, the wire should be pulled firmly back through the hole where it was first inserted; once tight, the wire is wound around a second wire tack which is then driven into the wood of the end bar.

FRAME CONSTRUCTION

Grooved Top Bar Frame With Solid Bottom Bar

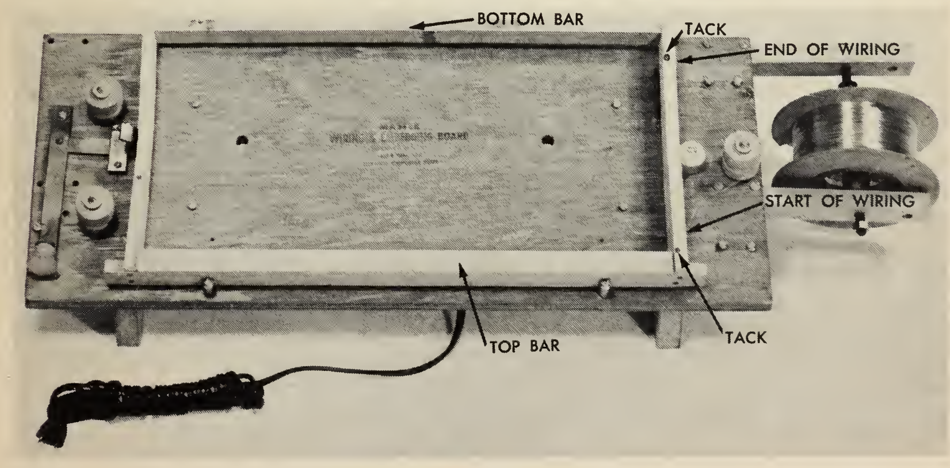


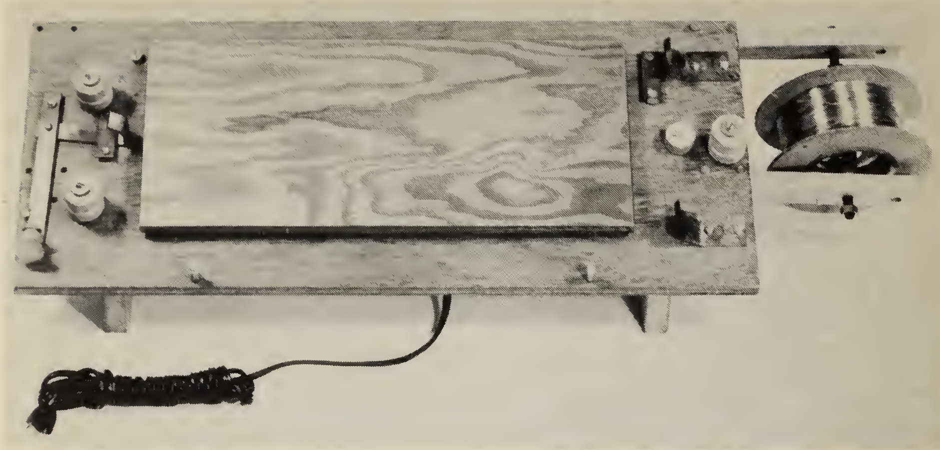
DEPTH OF FRAMES TO FIT:

HIVE BODY OR FULL SUPER	$9\frac{5}{8}$"	= $9\frac{1}{8}$"	FRAME
THREE-QUARTER SUPER	$6\frac{5}{8}$"	= $6\frac{1}{4}$"	"
SHALLOW SUPER	$5\frac{3}{4}$"	= $5\frac{3}{8}$"	"
COMB HONEY SUPER	$4\frac{5}{8}$"	= $4\frac{1}{2}$"	" OR
		$4\frac{1}{4}$"	COMB SECTIONS

Frame for beehive.

Jig for wiring frame (frame in place) can be modified for embedding wires in foundation also.



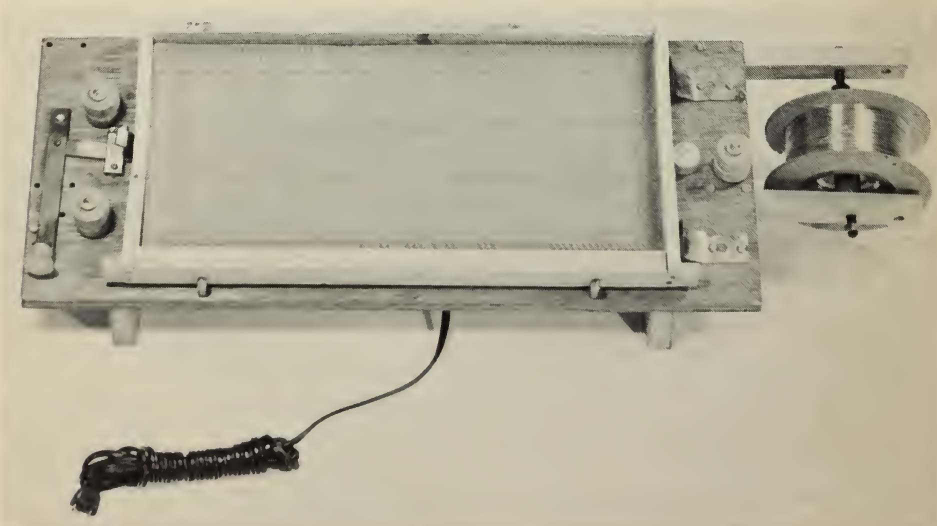


Same jig as in preceding photo, but with board placed in center to support foundation in which wires will be embedded. (Here the frame has been removed to show board more clearly.)

Embedding foundation in frame. Place foundation on a board of the same size and place the wired frame over this (see the photo below). After doing this, run a heated spur-embedder over the wires, pressing heavily enough to embed wires in the foundation. This should not be done on foundation colder than 70°F. because the wax will warm up in the hive, and will expand and pull loose from the wires.

An electric embedder is useful when many frames are to receive foundation. An electric train transformer of 6 to 10 amperes capacity and adjustable voltage can be used to power such an embedder; a door bell transformer can also be used—it should have a 6 to 13 volt secondary rated at no more than 5 amperes. *Do not use a cone heater in series with the embedder and plugged into a 120-volt power*

Wired frame with foundation ready to be embedded; the foundation is in place underneath the wires of the frame. Electric cord for embedder is connected to transformer on back of jig.



line—this is extremely dangerous because one of the electric contacts is electrically alive and can cause severe shock.

Other equipment

Smoker. When bees are smoked they hurriedly gorge themselves on honey and are then less inclined to sting. Smoker fuels used may be burlap sacking, coarse wood shavings, or other materials that will give a cool smoke and will not go out easily. Only enough smoke to control the bees should be used.

Veil. Wire veils are commonly used because they do not blow against the face. Meshed tulle veiling with a silk tulle face for better vision may also be used.

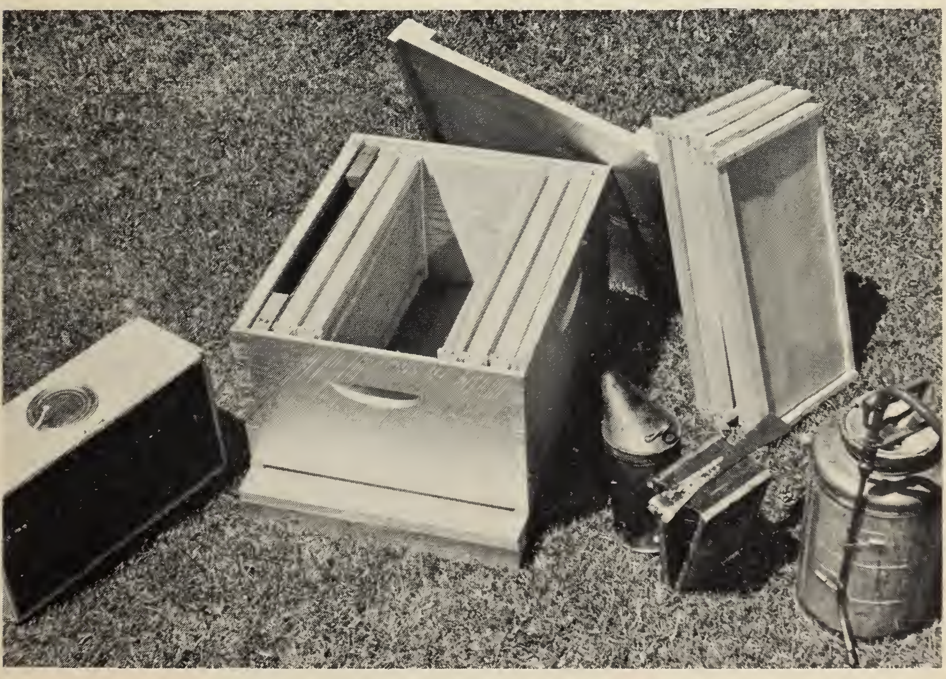
Gloves. Experienced beekeepers seldom use gloves because they make the handling of frames more difficult, but a pair would be handy for an amateur working angry colonies.

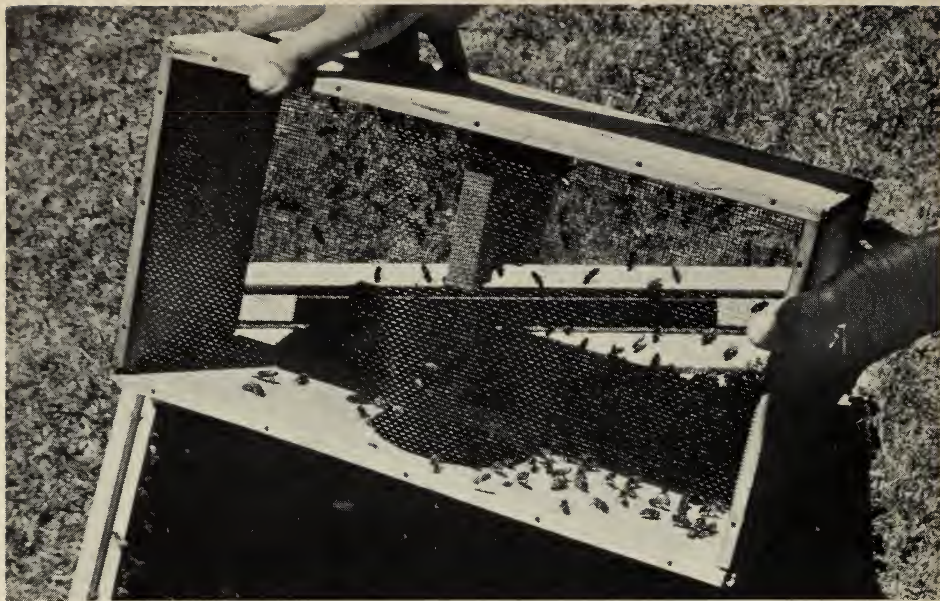
Hive tool. This is an essential tool because it has many uses, such as prying supers and frames apart, scraping hive parts, and hammering.

Queen excluder. To insure that the queen will lay no eggs in combs to be used for honey storage, a queen excluder may be used in each hive. This is a grid of perforated metal or a metal grill made of round wire bars placed 0.163 of an inch apart so that workers can pass through it but drones and queens cannot. An excluder is placed between supers to restrict the queen to those supers below the excluder.

Honey extracting equipment. To extract honey produced by the colonies, an extractor, uncapping knife, cappings receptacle, strainers, and honey settling tanks are needed. With a 2-frame extractor honey from 25 colonies can be processed. Extracting processes and equipment used are described in more detail, starting on page 25.

Hive body ready for packaged bees (four frames removed from center). The package of bees (left) has syrup can and queen cage in center—note top of can on package. Can and cage are removed before bees in package are shaken into hive body.





Shaking packaged bees into hive. Queen cage and syrup can have been removed.

THE COLONY

The well-established colony. A colony should have one queen, 20,000 to 60,000 workers, and (in summer) about 600 drones. A characteristic pattern is found in healthy colonies: the outer frames of comb in each hive body are filled largely with honey and pollen, and nearer the center of the hive body, there will be three or more frames of brood. By holding one of these frames so that light will reach the bottom of the comb cells, you will be able to see eggs or larvae in many of the cells. (All honey bees go through an egg, larval, and pupal stage before becoming adults.)

When cells are filled with honey, worker bees cap them with wax; cells containing pollen usually are only partly filled and not capped. Sometimes, however, bees may place honey on top of the pollen and when these cells are capped they appear to be full of honey.

The queen. The life of the colony depends on the ability of the queen to lay eggs. A good queen lays 1,000 or more eggs a day in spring and summer. This is her chief function—she has no pollen baskets for collecting pollen or wax glands to secrete beeswax.

The queen develops from a fertilized egg as does the worker, but unlike the worker she is fed royal jelly during her larval development and entire life. This jelly, a richer food produced by worker bees, produces an adult queen in a shorter time (16 days) than it takes for a worker bee to develop from egg to adult (21 days). Unlike workers, the queen's wings are shorter than her body, which is long and tapered. About 6 to 12 days after leaving her cell, the queen mates with numerous drones during a brief mating flight. The sperm received is stored in a sperm sac and released when an egg is to be fertilized. Within 10 to 14 days after leaving the cell, the queen begins to lay eggs (if queens do not mate they will lay unfertilized eggs, and these produce drones only). Productive, and populous colonies need good, young vigorous queens, and therefore many beekeepers put a new queen in each colony annually —this is known as "requeening."

The queen has a sting, but she usually uses it only to destroy other queens in

Queen bee (center) and worker bees.

the hive when she first emerges from her cell.

The worker. Three days after the queen has laid a fertilized egg it hatches. To produce workers, the larvae are fed only royal jelly for their first 3 days of life; for the next 5 to 6 days they are fed a mixture of honey and pollen. After this feeding period, the larvae are sealed in their cells by porous wax caps placed over the cell by worker bees. The larvae then line their cells with cocoons of silk-like threads and change to prepupae. During the pupal stage, larval organs are replaced by adult-like organs. The adult workers, who are always female, emerge from the cells on the 21st day after chewing the caps off. Immediately after this they groom themselves and start to eat honey and pollen; the body wall then hardens, and the new workers are ready to begin their many chores.

Workers do all the labor of the colony such as cleaning cells, feeding larvae, cleaning the hive, evaporating water from honey, secreting beeswax, building comb, guarding and ventilating the hive. When about 3 weeks old, they begin to forage for pollen and nectar, water and propolis. Workers live for 4 to 6 weeks during the nectar and pollen-collecting season (spring and summer). Winter worker bees live several months.

The drone. The chief function of drones is to mate with the queen and provide sperm for fertilizing her eggs. Drones have no sting, pollen-collecting structures, or wax glands. Drones develop from unfertilized eggs to adults in 24 days; they live for 6 to 8 weeks during the summer, and are fed by the workers. In queenless colonies workers sometimes lay a few unfertilized eggs; these eggs produce only drones. Drones have bodies shorter and more square than those of workers, and their eyes cover most of their heads.

Annual colony cycle. The yearly cycle of the colony begins when blossoms first appear in spring and workers start to gather pollen and nectar. The queen's egg-laying greatly increases, with consequent increase in colony population. When the colony becomes crowded with brood, pollen, and honey (usually in late spring) the colony may swarm. This is a process of colony reproduction (see page 16 for further discussion). Preparatory to swarming, workers build queen cells along the bottom and sides of brood combs; workers also feed the old queen less, and she gradually reduces the number of eggs she lays. Foraging is reduced as scout bees seek a home for the swarm. Shortly before the new queens emerge, most of the colony clusters into a group or swarm. The swarm usually leaves the hive in early afternoon, producing a sound which is unique and heard only at this time. The swarm may cluster on a nearby limb from a few hours to a day or more before flying to its new home where it will again function as a colony. Swarms rarely stay outdoors for more than a few months, but occasionally an open-air colony will survive long enough to produce large clusters of comb.

The part of the colony left after a swarm departs has many frames of brood, a reduced population of worker and drone bees, and queen cells with queens in different stages of development. The first queen that emerges usually finds the other queen cells and stings the queens inside. The workers then finish the destruction of the unemerged queens by tearing their cells down and discarding them from the hive. In 6 to 10 days after emerging, the new queen takes her mating flight and about 3 days after mating she begins laying eggs.

While nectar and pollen are available, colonies gather and store as much as they can. As the nectar flow wanes, drones usually are driven out of the hives (usually this is at the end of summer); brood rearing gradually declines and the colony population dwindles from about 60,000 to 20,000 or less. In late summer and fall worker bees bring in more propolis to seal the hive tight against winter weather, but as the weather gets colder the bees are less active. When temperatures reach approximately 57°F, they cluster in the hive; at lower temperatures they cluster more tightly and the insulation produced, plus the activity of the bees within the cluster, maintains the temperature within the cluster. The cluster forms on combs of honey, and as the honey is used the cluster moves to new combs of honey. In central and southern California, bees fly during most of the mild winter; therefore tight clusters are formed only during a few days of colder weather.

Colonies wintered in 2-story hives eventually move onto the combs of honey in the upper story during the winter. In mid-spring, the beekeeper usually moves the brood and the bees to the lower story to allow the bees to expand upward.

MANAGING BEES

Management practices vary according to time of year and the type of operation being followed: the production of honey, or of packaged bees and queens, or rental of bees for pollination. The following section describes common factors of management for all these operations.

Spring management. In early spring an inspection should be made to determine the size and health and the food supply of the colony. The colony should have five frames covered with bees, and there should be at least three frames full of honey for food. Too few bees may indicate a queenless colony and therefore the colony should be searched for presence of its queen. Queenless colonies should be united with queenright colonies (colonies having a queen), or a laying queen should be introduced. After the first major spring-blooming period, a strong colony will have six or more frames covered with bees in a 10-frame 1-story hive, or 12 frames covered with bees in a 2-story hive, and brood covering 75 to 100 square inches on both sides of four to five frames in the hive body. Under these conditions, brood rearing will increase rapidly and the colony will build up to a maximum population for the beginning of the major honey flow period. Only a few days of abundant spring honey flow are needed to crowd the brood chamber of a 1-story hive with honey and pollen, so a super with frames of empty combs should be added to the hive when the flow begins. Frames with foundation alone should be provided only if the bees are gathering an abundant supply of nectar. The best practice is to place frames of drawn comb among those frames having foundation only.

Brood rearing puts a heavy demand on the food supply and therefore, it is important to keep a close check on all colonies during March, April, and May in northern California, and as early as December, January, and February in southern California (south of the Tehachapi mountains).

Summer management. Spring pastures may prove inadequate for summer, and feeding may be necessary. Therefore, enough inspections should be made in

summer to ascertain if there is sufficient natural food in the hive; at least 30 pounds of honey at one time should be in the hive in summertime. (When inspecting hives it is also advisable to check for disease—see pages 38–42.)

Honey crops should be harvested when frames in supers are full of honey and before queens are "blocked out," which occurs when too many brood-comb cells are filled and the queen has no egg-laying space. Colonies need new pasture to remain productive, and in California this means moving commercial apiaries hundreds of miles to plant pasture. Therefore, the commercial beekeeper must know the annual blooming sequence of pasture plants to plan his season's moving schedule.

Fall and winter management. The ideal colony for fall and winter conditions is disease free, contains a vigorous young queen, and has ten or more frames covered with bees. If the fall population of a colony is less than ten frames of bees, the hive should be reduced to a single hive body and a super full of honey. Queenless colonies, or those sparsely populated, should be united with stronger queenright colonies and each colony should start the winter with at least 50 pounds of honey for its winter food supply (10 full-super frames filled with honey weigh approximately 50 pounds). Surplus honey, pollen, and brood in a colony can be transferred to needy colonies if no brood diseases are present in the first colony. Transferred brood frames should be placed together so that bees can cluster around the brood. Extra feeding may be necessary. Each colony should have a vigorous young queen and should be inspected for disease.

Winter beekeeping chores in California include repairing, painting, building new equipment, and fumigation of frames of comb in storage. In autumn, colony entrance openings should be reduced in diameter to 1 to 2 inches across, and in winter they should be checked to be sure they are open. Hive covers should be fastened to the hive so they are water- and wind-tight. Entrances should not face prevailing winter winds.

Feeding bees. Pollen, honey, and water are the basic ingredients in the natural diet of honey bees. Pollen contains protein, and carbohydrates are found in honey; bees require water as do other animals, and they also use it to cool their hives. Only adult worker and drone bees can live mainly on honey or on sugar syrup; they require little pollen, but when functioning as nurse bees workers need honey, pollen, and water to secrete royal jelly.

Many California beekeepers use various mixtures of pollen, sugar, and artificial foods to increase colony population. Bees are fed to:

• build-up population to compensate in part for pesticide losses.

• build-up population for winter.

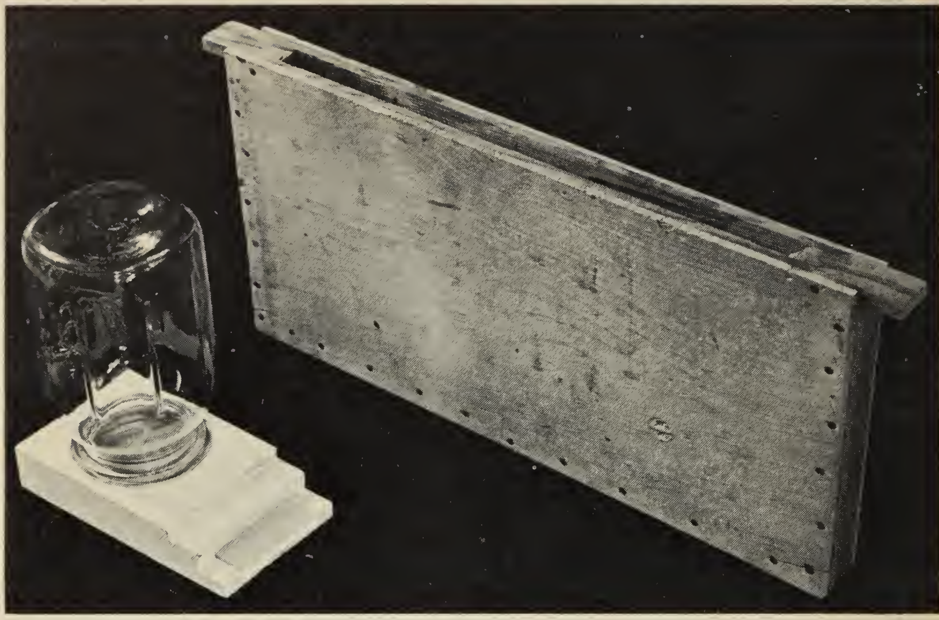
• build-up population for spring pollination of almonds.

• build-up population in the spring for shaking bees for packages.

• compensate for nectar dearths occurring at various times every year, especially in early spring. Colonies may need to be fed at these times unless honey (30 to 50 pounds) is kept in the hive. Colonies occasionally are fed sugar syrup between nectar flows in order to maintain active brood rearing and colony population. This is successful as long as the bees also have sufficient pollen in their combs or are collecting it. They cannot raise brood on sugar syrup alone.

Worker bees may consume a frame of honey and pollen for each frame of brood they rear; a colony having a prolific queen (1000 eggs daily) may need 10 pounds of pollen a month to rear larvae.

To increase the queen's egg-laying rate in spring, colonies should be given combs of honey or sugar syrup, or dry sugar with pollen or pollen substitute—one or two frames of honey may be placed adjacent to frames holding brood. (*Unless a colony has been free of American foulbrood disease for at least 2 years, combs of honey from it should not be fed to other colonies because this disease can be carried as spores in honey.*) Sugar syrup can be fed from a jug, a friction-top can, or from Boardman or division-board feeders. If a



Left: a Boardman feeder. The wooden bottom below jar is inserted into hive entrance and syrup flows from jar through holes in its cap. **Right:** the Doolittle wooden division board feeder can be filled with sugar syrup and inserted in hive after removing a frame to make room for it.

jug is used, its cap should have an ⅛ inch hole punched in it; the jug is placed cap-down in a cap-sized hole on top the hive. If a can is used it should be placed so that its top (punched with six or eight holes) rests on the top bars of the frames and an empty super and cover should be put on the hive to keep the can warm enough for the syrup to flow well. Boardman feeders are placed on the front entrance of the hive, and division board feeders are placed inside the hive in place of a frame.

Sugar syrup for feeding between nectar flows consists of one part sugar and one part water by volume or weight. For winter feeding, syrup of two parts of sugar and one part of water by weight or by volume is used. When colonies are fed in cold weather sugar may be increased to 2½ parts to one part water, with a teaspoon of cream of tartar added to every 20 pounds of sugar to keep the syrup from granulating. Boiling water is needed to dissolve the sugar.

Extracted honey may be fed instead of sugar, but it must be from disease-free colonies, and it should be diluted ¼ to ½ with water. Feed a quantity of diluted honey that can be consumed quickly (24 hours) before it begins to ferment.

Dry table sugar can be liquefied by bees if they have access to water. Usually 1 to 2 pounds is poured into the entrance so that the sugar flows to the back of the hive and the entrance is not closed. Ordinary table sugar or confectioners sugar, or both, can be used—the latter contains 9 per cent of simple or invert sugars which absorb water from the air and make the sugar more attractive and edible for bees.

To build up a population by artificial feeding, a supply of pollen in the colony or an adequate pollen substitute is essential—sugar alone will stimulate the queen to lay, but she will not be able to sustain her laying. Additionally, bee larvae will not obtain complete nutrition if there is no source of protein. Combs of pollen may be stored and placed in hives as needed. If pollen is not available, a supplement or substitute must be given to sustain egg-laying by the queen.

Mixtures of sugar, soybean flour, pollen and a dried concentrate of whey-grown yeast and milk albumin (Wheast®) are used by California beekeepers. Combinations of these are made into dry or moist cakeforms containing about 8 to 10 per cent protein (although some beekeepers use mixes containing as much as 24 per cent protein).

Examples of mixtures used:

• One hundred pounds of Drivert® sugar (91 per cent sucrose-table sugar and 9 per cent levulose and dextrose sugars); 10 pounds of Wheast; 5 pounds of soybean (expeller processed) flour. This is approximately a 9 per cent protein mixture. It is usually fed as a dry mixture at the rate of 1 pound to each colony per week.

• Drivert and Wheast combined—80 per cent Drivert and 20 per cent Wheast. This is approximately an 11 per cent protein food; it is usually fed dry at the rate of 1 pound to a colony per week.

• Three pounds of pollen; 5 pounds type-50 warm sugar syrup (77 per cent sugar and 23 per cent water—this sugar is one-half sucrose and one-half levulose and dextrose); 8 ounces (one-half pint) of warm water. Mix together and added to the following ingredients after they have been mixed: 30 pounds of type-50 warmed sugar syrup, and 25 pounds of Wheast. This 24 per cent protein mixture will be a semi-liquid mass which can be formed into 1-pound cakes. A 1-pound cake of the mixture is usually fed to each colony per week.

• Five pounds pollen, 55 pounds of type-50 sugar syrup, 39 pounds of Wheast and approximately 1 pint (1 pound) of water to prepare 100 pounds of mixture. The pollen, water, and 8 pounds of type-50 sugar syrup are mixed first. To this is added the remaining sugar syrup and Wheast to form a semi-solid mix that can be formed into cakes, which are then placed on the top bars of the frames in the hive body.

Pollen grains are living cells and therefore require the following special harvest and storage treatments to prevent loss of nutritive value.

Freshly trapped pollen may be mixed with half its weight of fine granulated sugar, tamped down tightly into pails or drums and tightly sealed.* To guard against surface mold forming, it is best to sprinkle a ½-inch layer of additional sugar on top of the pollen before sealing. This mixture can be stored at 70°F. The pollen remains soft and moist and can be formed into cakes and fed directly to the bees, or mixed to form a pollen supplement.

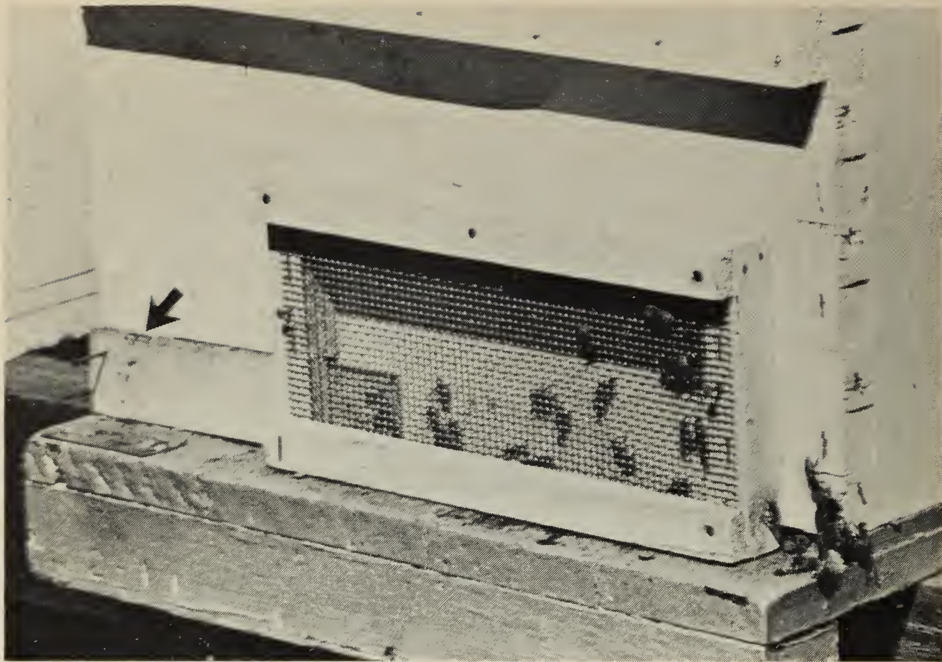
Fresh pollen may also be placed in containers and stored directly in the deep freeze at approximately 0°F. The pollen keeps its nutritional value for at least several years, but should be used immediately upon removal from the freezer. Such pollen is moist and crumbly, and is readily mixed with other ingredients to prepare a pollen substitute or food supplement. Pollen used as bee food should be free of disease and pesticide residues.

PREVENTING ROBBING AND SWARMING

Robbing. Bees occasionally rob honey from other colonies and may even destroy the colonies in doing so. Robber bees can usually be recognized by their attempts to enter cracks between supers. To protect colonies, use robber screens (photo, page 16) over hive entrances; these screens provide more ventilation than would be obtained when entrances are partly closed by solid objects. When examining colonies for possible robbers do not keep them open any longer than necessary, and put the frames of honey in a super covered with wet burlap during inspection.

The risk of robbing can be reduced by feeding bees in the afternoon—if bees are fed in the morning, the excitement of feeding lasts all day and this may attract robber bees.

* This method of pollen storage was developed by G. F. Townsend and M. V. Smith of the University of Guelph, Ontario, Canada.



Robber screen at hive entrance. Board at left (arrow) closes most of the entrance not covered by the screen. Entrance to hive (extreme right) is now about 1 inch long.

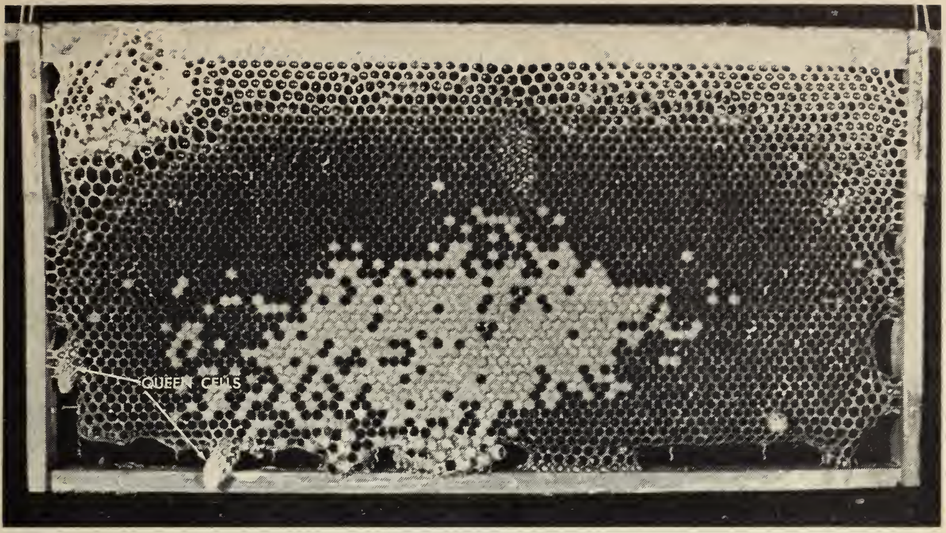
Swarming. Swarming reduces the colony population, so it should be prevented or controlled. To minimize swarming:

- Provide plenty of storage room for surplus honey by adding supers with frames of drawn comb or foundation before the colony becomes too crowded.
- Provide the queen with ample egg-laying space by adding frames of disease-free drawn comb, or by using two hive bodies, one above the other—these should be reversed when the queen is in the top body and when its frames are filled with brood and covered with bees.
- Head the colonies with young, vigorous queens.
- Provide sufficient shade for the hive during the hottest part of the day. In desert areas, total shade is needed during heavy honey flows.
- Provide adequate watering places.

Swarm control can be combined with requeening. If a colony is ready to swarm, there will be at least one queen cell on the comb. To requeen, select one queen cell that is well developed and destroy the others. Also find the old queen in the colony and kill her by pinching her head. The new queen will emerge from her cell in a few days and thus requeen the colony.

Demaree swarm control method. Many special methods are used to control swarming. The Demaree method is as follows:

- Destroy all queen cells.
- Place one comb of unsealed brood with the queen on it into a hive body. Fill the remaining space with frames of empty comb.
- Place a queen excluder on top of hive body.



Queen cells on bottom and side of comb. In spring, the queen cells are usually found on the bottom of combs.

• Place super or supers on top of (above) excluder on hive body.

• Place remaining combs with brood and bees in super or supers on top of (above) excluder.

• After 10 days, examine supers on top of (above) excluder for queen cells and destroy any found.

In 3 weeks all of the brood will have emerged from the comb in the supers above the excluder, and the comb will be used for honey storage. Bees will begin to emerge from new brood in the hive body, and a continuous supply of bees is produced. It is not often necessary to Demaree more than once.

MANAGING BEES FOR POLLINATION

Pollination is essential to most flowering plants for producing fruits and seeds, and in California the honey bee is the most important pollinator of commercial crops. Beekeepers rent their colonies for this purpose by placing them in or around crops, and highly developed transportation techniques have been worked out for moving colonies from area to area as they are needed.

Many beekeepers have legal contracts with growers for pollination services. A written contract between beekeeper and grower should:

• Set times when bees will be moved in and out of fields or orchards.

• Assure that no pesticides harmful to bees will be used. (If it is necessary to use pesticides, notice should be given to beekeeper.)

• Assure beekeeper of reimbursement for extra movement of colonies in and out of the field.

• Define population of colonies in terms of numbers of frames covered with bees; or of number of frames covered with bees and number of frames with brood; or of number of frames covered with bees and having a certain amount of square inches of brood.

• Describe distribution of colonies in fields or orchards.

• Include agreement that the beekeeper will maintain bees in good condition, provided they are not damaged by pesticides while under contract.

• State rental fee to be paid.

• State who is responsible for supplying adequate water to bees.

Some of the most important factors affecting pollination are:

A strong colony for almond pollination. Bees cover at least six frames in hive body and four in super.

Number of colonies per acre. The number of colonies of bees used per acre depends on the kind of crop, the population of the colonies, the weather, and the amount of competing blooms in the area of the crop. Two colonies per acre in most crops are enough to insure optimum numbers of bees during the most unfavorable conditions for pollination. For alfalfa seed crops, approximately three colonies per acre are commonly used; however, alfalfa seed yield has sometimes been increased by using four to five colonies per acre. In melon pollination, one colony per acre is often used, but two colonies per acre is considered better.

Colony strength. The California State Beekeeper's Association has set its official minimum standard for almond pollination at four frames of bees with a laying queen

per colony and two colonies per acre; for alfalfa pollination there must be 600 square inches of brood and five frames covered with bees. Because honey bee colonies in alfalfa seed fields usually decline in population, its is good practice to employ supplemental feeding before bees are introduced into the field and while they are in it.

Distribution of colonies. Because bees tend to work close to their hives, in attractive pasturage, hives should be distributed at 1/10- to 1/4-mile intervals. If the field is less than 100 acres, or the orchard is less than 40, colonies may be placed in two or more groups around the edge of the crop. For long-sided, narrow, rectangular fields groups of colonies on each long side give better distribution.

Plant competition. Honey bees may visit plants other than those to be pollinated if such plants provide more attractive pollen or nectar. To prevent bees from visiting competing flowers, colonies should be moved into the field or orchard after the beginning of bloom when there is sufficient forage to hold bees in the crop. It may be advisable to destroy cover crops in orchards to reduce competition.

Weather. Bees begin to fly at temperatures of about 55°F. They do not fly in rain or in wind of more than 15 miles per hour. Temperatures of over 100°F. reduce flight activity.

Pesticides. Bees provided for pollination service need maximum protection from damage by pesticides. Colony populations reduced by losses caused by pesticides applied to the crop during bloom may not be able to regain their original population during the relatively brief pollination period. Their effectiveness as pollinators may be impaired for several weeks or months before they recover from such damage.

Bees in orchards or fields are sometimes exposed to pesticides from adjacent areas; therefore, colonies should be moved as soon as possible after pollination to avoid pesticide damage. The beekeeper should check with managers of crops adjacent to where his bees are pollinating to make sure that foraging bees will not be injured by pesticides on those crops.

Maximum protection can be obtained by using pesticides that are least toxic to honey bees and applying them at night when bees are in their hives. Beekeepers should suggest that the grower use materials least harmful to bees, and that he pick safest times for application.

Bees usually receive maximum protection when the beekeeper, the grower and his neighbors, and the pesticide salesman and applicator work closely together.

QUEEN CARE, REQUEENING, AND QUEEN INTRODUCTION

Care of queens. Frames should always be handled carefully so that the queen is not injured. The first frame removed from the hive during any inspection of queen and brood should be the second one in from the hive wall (outer frames seldom have brood or queen cells). Always set this frame against the side of the hive and out of the sun. Never set the frame with the queen on it outside the colony without protecting it with another frame.

Do not examine colonies if they contain virgin, newly introduced, or recently mated queens. These queens and their attendant bees are nervous and the disturbance caused by opening a hive may cause the workers to harm her.

As a rule the queen should not be handled. If it is necessary to pick her up, catch her from behind by all four wings with the index finger and thumb. Queens can be seen more easily if marked with a color, and by using a different color each year the queen's age can be readily determined. Fingernail polish or other quick-drying paint may be applied on top of the thorax between the base of the queen's wings.

Requeening. Requeening is done to replace a queen of poor stock or one which is getting old. The colonies can be requeened at any time in the active season, but usually are requeened during a nectar flow because the new queen is more readily accepted then. Before introducing a new queen, the old queen should be removed and any queen cells present should be destroyed.

Queen introduction. Queens may be purchased from bee-supply houses, and they are usually shipped in a cage which also contains a few attendant bees. The cage has an opening which is plugged with bee food known as "candy"; the attendant worker bees will use the candy to feed the queen during time of shipment. To introduce a queen from a cage into a hive body, the cork which covers the opening containing the candy plug must be removed, after which the entire cage is placed in the hive body. The cage should be placed between the top bars of two frames by pressing the bars gently together so that they hold the cage in place, with the screen side of the cage facing down. The bees in the hive will consume the remaining candy, thus releasing the queen and her attendants. This will take long enough, however, for the bees already in the hive to grow accustomed to the new queen's presence.

Instructions for introducing a queen shipped in a cage in a package of bees will be found on page 3.

MAINTAINING BEE STOCK

Good stock is essential to successful beekeeping. Such stock can be obtained from many of the commercial queen breeders, and can be maintained if care is used in propagation. However, production of stock which is better than that currently available is usually beyond the resources of the beekeeper, because breeding requires the use of artificial insemination and a working knowledge of genetics.

In maintaining his stock, the beekeeper must decide which characteristics are most important to him, and he must confine his efforts to preserving these. He must also decide on how a colony can be described, so that he has some way of comparing colonies and measuring the results of his efforts.

Importance of environment and heredity

High per-colony-yield of honey is a desirable goal of bee breeding, but it is not a simple genetic characteristic. Yield is influenced not only by management and honey flows but also by the number and activities of bees in the colony. The population, in turn, is determined by the egg-laying rate of the queen, the viability of eggs and larvae, and the longevity of adult bees. In stock maintenance, as in breeding, each of these must be considered. Other characteristics which should be considered are gentleness, and resistance to disease; each of these is probably dependent upon several hereditary factors.

The characteristics referred to are products of the development of bees from germ (reproductive) cell to adult, and result from the interaction of environment and the determining factors in the body cells. The germ cells of the queen bee develop into eggs, and the germ cells of the drone develop into spermatozoa. The eggs and spermatozoa are known collectively as gametes. The determining factors (genes) are transmitted from parent to off-spring through eggs and spermatozoa. Genes are located in the chromosomes of cell nuclei and are arranged one beside the other like beads on a string.

Maturation of germ cells. Germ cells of both sexes increase in number by cell division, but before they become gametes and are functional they must undergo a process called maturation. The body cells and the immature germ cells of a queen honey bee have 32 chromosomes which are paired—that is, each chromosome has a mate of identical size and shape.

One member of the pair comes from the queen bee through the egg, and the other member comes from the father through the spermatozoon that fertilized the egg. The two members of each chromosome pair are homologous (like-chromosomes); each chromosome of the pair is the homologue (copy) of the other. Thus, there are 16 pairs of homologous chromosomes in the cells of the female bee and they form two sets of 16 chromosomes each, a set consisting of one member of each pair. An organism with paired chromosomes is said to be diploid. The drone, which has one set in each cell, is said to be haploid (total chromosomes, 16). When the egg matures, which occurs about the time it is laid, one member of each pair of chromosomes is eliminated from the nucleus, leaving the egg with one set—that is, 16 chromosomes. This is accomplished by a special process of division of the nucleus of the egg called meiosis.

Maturation of male germ cells does not reduce the number of chromosomes, as the germ cells have only one set of chromosomes (one member of each pair) to begin with.

Restoration of the diploid conditions results from union of male and female gametes. As it is laid, the micropyle of an egg destined to become a female bee is pressed against the opening of the spermathecal duct until one or more spermatozoa enter the egg. The cell resulting from this union is a zygote, from which the bee develops.

If the egg is destined to become a male bee, it does not receive spermatozoa as it is laid. The egg divides by mitosis (splitting of chromosomes) to begin the development of the drone. The matured egg nucleus has only 16 chromosomes, and since no sperm has been introduced the drone has only 16 chromosomes. The development of an egg without uniting with a sperm is known as *parthenogenesis*.

Basic requirements of stock maintenance

Critical selection of parents, good queen-rearing methods, and an abundance of mature drones from selected mothers are essential. Selection of drone mothers is as important as selection of virgin-queen mothers. The same characteristics are essential: solid brood pattern, gentleness, and resistance to disease. If bees are to be used primarily for pollination, pollen-gathering ability may be preferred to honey yield.

Breeding. One or more queen mothers should be used for production of queens, and several drone mothers for production of drones. Drones in queen-mother colonies should be kept to a minimum, while drone-mother colonies should be given drone comb to encourage the production of an abundance of drones. Queens mate with 10 or more drones on a single mating flight, so it is important to have a great surplus of drones to assure that the virgins mate with the proper drones.

Almost any colony can be induced to build queen cells, but the quality of queens produced will vary with the care the developing larvae receive. To produce good queens, the colony must have an abundance of nurse bees and of pollen and honey or sugar syrup. Nurse bees can be provided by making sure the colony has a comb of emerging brood a week before grafted cells are given to it, and an ample supply of royal jelly can be assured by removing much of the young brood a few hours before grafting. (Grafting is the transfer of young larvae from worker cells to queen-cell cups—see text, page 22). A day or two prior to grafting, a comb with pollen should be placed in the colony next to the space to be occupied by grafted cells. Sugar syrup can be fed in a Boardman feeder, or by inverting a friction top pail with several small holes in the lid over the frames and inside an empty body. The queen cells should be distributed to mating nuclei or to colonies to be requeened on the 10th day following grafting, and the virgin queens should emerge the following day.

Queens usually mate when about 7 days old, and begin laying 3 to 4 days later. When the queen mates (in flight), the semen from the drones is deposited in her oviducts. The sperm move into the spermatheca during the next 15 hours, approximately, and remain there until used or for the life of the queen. The movement of the sperm from the oviducts

to the spermatheca is slowed by temperatures below 80°F. Therefore, it is important that the nuclei or colonies be strong enough to maintain a temperature at least this high in the brood area after the queen returns from her mating flight.

QUEEN BEE PRODUCTION

This is an industry within the beekeeping industry which, in the Sacramento Valley, produces approximately 400,000 queens and 550,000 pounds of packaged bees annually for U. S. and Canadian markets—a $1,500,000 yearly business. Skilled beekeepers with many years of experience maintain the queen-production industry, but the following common commercial procedure can be modified to suit smaller operations.

Queens are produced by placing (grafting) 1-day-old larvae into cell cups made of pure beeswax, and then putting the cups into a cell-builder colony. (This is a colony having a dense population of worker bees.) In such a colony worker bees will feed royal jelly to the larvae until they become pupae—this assures that they develop into queens, not workers.

To start this procedure, empty cell cups are attached to bars long enough to fit between the end bars of a standard frame. The cell cups on the bars are then taken to a room suitable for the grafting operation. The temperature of this room should be at least 75°F. and the humidity around 50 per cent to prevent larvae and royal jelly from drying out; good bright light is important to help locate and remove larvae from the combs. A supply of royal jelly and a comb of day-old larvae should be in the room. A drop of royal jelly is placed in the bottom of a cell cup and a larva is put on the drop immediately afterwards (photo, page 23). This operation is repeated until all cell cups are full. The royal jelly keeps larvae moist and well fed (the jelly is usually diluted with an equal volume of warm water and stirred until it is an even consistency). Grafted cell cups are then placed in the cell-builder colony, which should be well supplied with sugar syrup, honey, and pollen.

After about 9 days in the cell-builder colony the cell-cups, which are now complete cells with queens, are put into an incubator (a modified chicken-egg incubator will do) kept at about 91 to 93°F. and a humidity of about 50 per cent. Ten days after grafting, the queen cells are taken from the incubator and cut from the bar. Each queen cell is placed in a small hive (nucleus or "nuc" hive) containing about a quarter-pound of bees; these will take care of the cell until the queen emerges. A few days after emerging, the queen flies out and mates with drones after which she then returns to the nucleus and in 3 or 4 days begins to lay eggs. The beekeeper then removes the queen from the nucleus and cages her for shipping.

When shipping queens to buyers, the queen can be shipped in a cage along with a few attendant bees and a supply of food. When shipping queens and enough bees for a colony, the queen is sent in a cage placed in a package full of bees which also has a container of sugar syrup —the bees will feed the queen through the wires which enclose her cage.

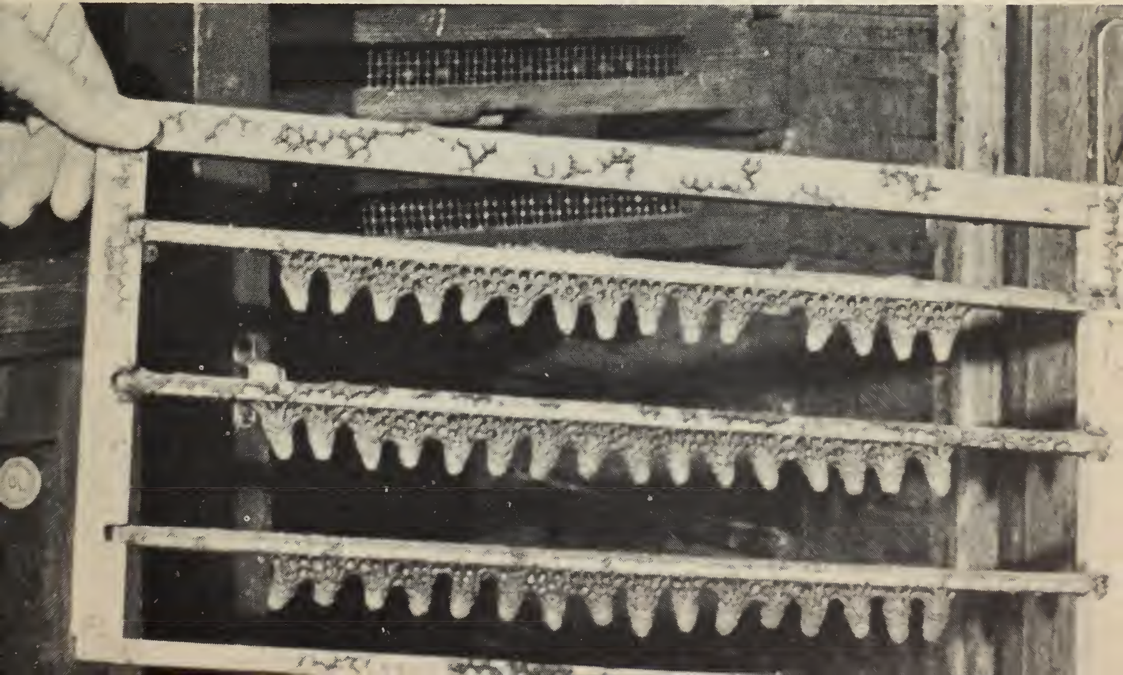
PACKAGED BEE PRODUCTION

This is an enterprise for experienced beekeepers, but the procedures described below can be modified for hobbyist operations.

The bees should be fed well in January and February. This stimulates the queen to lay eggs early and thus results in large populations per colony to take maximum advantage of early spring blooms. With such strong colonies the beekeeper may place his bees in almonds in February and in manzanita in March. By following this

Grafting larvae from comb into queen-cell cups. Bright light and right temperature are needed here.

Frame with grafted queen-cell cups after removal from cell-builder colony. Incubation is the next step.



procedure the beekeeper will be able to maintain colony population even though he removes many bees for packaging.

Removal of bees is done by what is known as "shaking." To shake bees, one or two frames are removed from each hive and shaken with a downward jerk over a funnel which empties into a "shaker box." The filled box is then carried to where the packages are being weighed; here the bees are shaken from the shaker box into a funnel that empties the bees into packages built for bee shipping. Two to four pounds of bees may be shipped in the packages, each of which contains a can of sugar syrup (except when shipping by air). The packages are nailed together with laths in groups of five; this makes them easier to handle and provides space for adequate ventilation when they are stacked. A 2-pound package is considered the minimum for a new colony; a 4-pound package may be divided into two colonies.

Below, left: shaking bees from super into funnel—the shaker box with screened sides (bottom) collects the bees; **right:** packages for shipping being filled from shaker box.

Loading packages of bees. Note that packages are nailed together with wooden strips.

HONEY: HARVESTING, SPECIAL PRODUCTION, TYPES

The definition of honey in the 1967 Agricultural Code of California reads: "Honey means the nectar of floral exudations of plants gathered and stored in the comb by honey bees. It is levorotary, contains not more than twenty-five one hundredths (0.25) of 1% ash, not more than eight (8) percent of sucrose, its specific gravity is not less than 1.412, its weight not less than eleven (11) pounds, twelve (12) ounces per standard gallon of 231 cubic inches at sixty-eight degrees Fahrenheit."

Honey is composed largely of two simple sugars, dextrose and levulose; enzymes, vitamins, minerals, and substances producing characteristic flavors. The average water content of California honey is about 17 per cent. Common forms of commercial honey are: extracted (liquid), comb, and crystallized (creamed or granulated).

Harvesting and extracting honey; comb-honey production; crystallized honey production; types of honey

Harvesting honey. When all combs in a super have been filled with capped honey (each comb should show two-thirds of its cells capped), the beekeeper may remove the super, after seeing that the hive has at least one super of pollen and honey for food. To harvest honey, bees have to be removed from frames, either by using escape boards or acid boards, or by using blowers, or by brushing bees off frames with a bee brush (when it is a small operation).

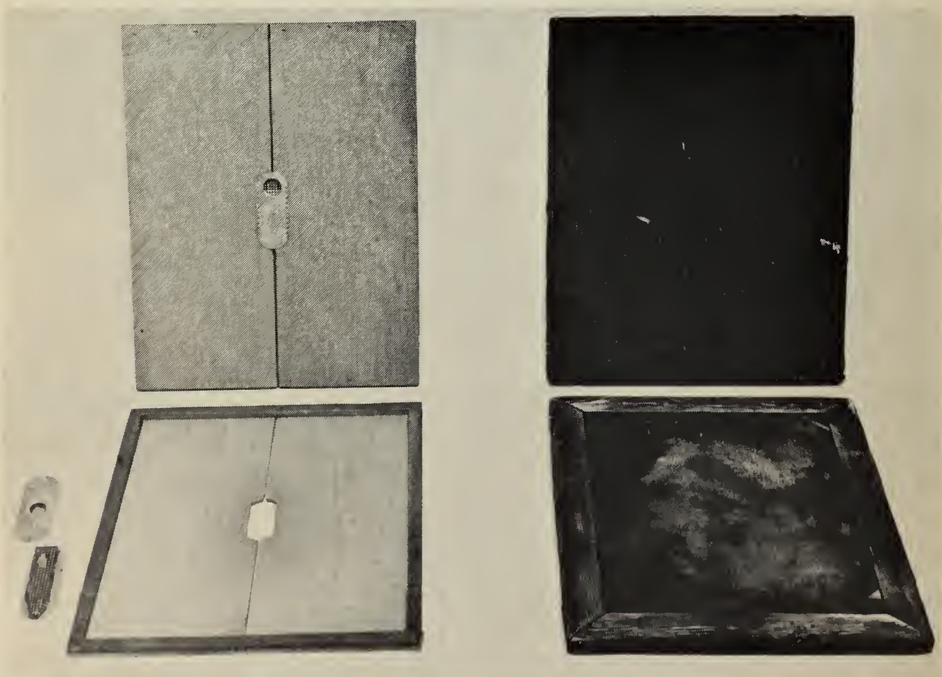
Bee-escape boards which allow the bees to leave but not to return to the hive, are

adequate for 50 or less hives. They are too slow and require too much costly labor for larger operations, although bees are disturbed much less with this method than with any other. Additional escape devices, which may be purchased from bee supply stores, may be placed in openings in one or more corners of the board to hasten removal of the bees. An escape board, placed under a super of combs filled with honey, will usually free the super of bees in 1 day. To prevent robbing, the super from which the bees are removed must be tight. If escape boards are left on in hot weather (100°F. or more) the combs may melt.

Acid boards are often used in larger commercial operations. These boards are metal hive covers each having a wooden frame 1-inch thick; a piece of hardware cloth is tacked across the top of the frame on the side opposite the metal cover; on top of this several layers of cheesecloth, muslin, burlap, or canvas are secured. A 50 per cent solution of pure carbolic acid or of 100 per cent benzaldehyde is then lightly sprinkled on the cloth surface. When these chemicals are used, the board is left on the hive only a few minutes (just long enough to drive the bees out of the top super). Carbolic acid works best on hot days in sunny weather because fumes are driven into the hive. Benzaldehyde works best at temperatures below 80°F—at higher temperatures it confuses and scatters them. In handling these chemicals, all safety rules should be observed in order to avoid their contacting the operator's body.

A bee blower saves time and money for the commercial beekeeper. Supers to be harvested are removed from the hive and placed on a stand; the bees are then blown onto the ground in front of the hive, but they are not injured nor angered. A bee brush can be used to remove the last few bees.

Extracting honey. In the honey house (where honey extraction takes place) combs containing honey must be moved through an uncapping machine, or uncapped with a hand-held knife, before



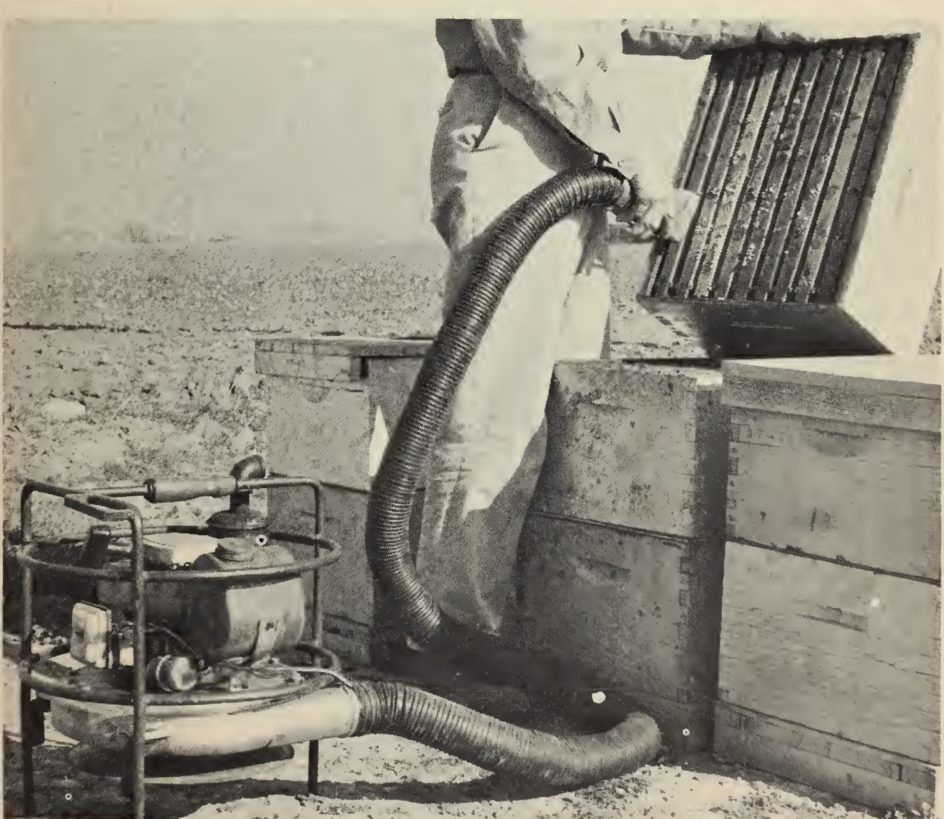
Left: bee escape board; note how bee escape (far left) fits into hole in board. **Right:** Top and bottom views of acid board, showing burlap lining on bottom section.

the honey can be extracted. (Damage to combs should be avoided so that they can be returned to hives for further use.) In the extractor, honey is removed from the cells by centrifugal force and flows downward to the bottom where it can be collected. The honey produced by 20 colonies can usually be handled with a 2- to 4-frame extractor, which can be operated by hand or by a small electric motor. For larger operations, extractors of up to 50-frame-capacity are available.

In operations requiring only a 2- to 4-frame extractor, honey is collected from the extractor in a container after passing through a sandwich strainer (made of two coarse wire screens with a fine strainer of nylon material between them) placed over the top of the container. The honey should be taken from this container as soon as possible and poured onto a flat surface extending to the bottom of the final containers. Flowing the honey over such a surface reduces the number of air bubbles trapped in the honey and gives it a clearer appearance.

In commercial operations, extracted honey flows from the extractor by gravity into a sump from which it is pumped into settling tanks where it usually loses air bubbles. A uniform flow of honey should be maintained to keep the pump full so that it will not beat air into the honey. If honey is thick and slow to flow, it may be heated to approximately 110°F. When honey is heated, some of its properties may be destroyed, so heating should be as brief as possible and the honey should then be cooled as quickly as possible. Wax particles in the honey will usually move to the top of the honey where they can be removed. The honey is drawn off from the bottom of the settling tank into drums, bottles, or cans. Extracted honey stores best at room temperature (70°F.±).

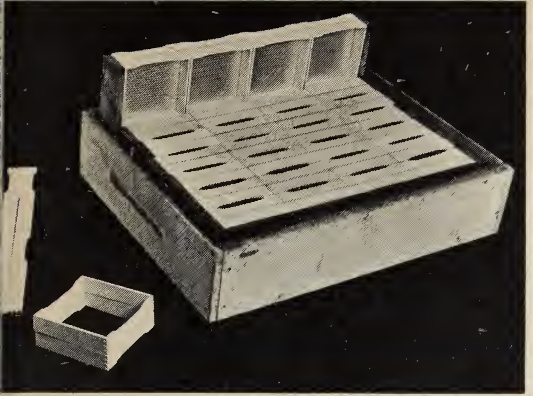
Bee blower driving bees from a super prior to harvesting honey from frames.



Working set-up for extracting small quantities of honey. **A:** 4-frame extractor; **B:** frame of honey ready for uncapping cells; **C:** electric uncapping knife; **D:** box with strainer to collect cappings and honey; **E:** sandwich-type filter for final straining. Four frames yield about 20 pounds.

Comb-honey production. Comb honey is produced in wooden square-section boxes sized $4\frac{1}{4} \times 4\frac{1}{4} \times 1\frac{7}{8}$ inches, or in rectangular boxes $4 \times 5 \times 1\frac{3}{8}$ inches which are placed in special comb-honey supers (frames are not used in these supers). The box tops should be painted with hot paraffin after they have been placed in the supers in order to prevent bees from staining the boxes with propolis. Overlapping honey flows of light and dark honey should be avoided for comb honey production because combs partly filled with dark and light honey are less attractive to consumers.

The production of comb honey is dif-



Comb-honey super filled with section boxes for comb-honey production. (Top boxes pulled up to show wax foundation.)

ficult because nectar flow has to be constant and abundant to produce combs of good quality, and because colonies have to be crowded almost to the swarming point before bees will go into the comb-honey boxes. For best comb-honey results there should be enough bees in the colony to fill at least a hive body and a full-depth super; a super of empty comb-honey section boxes should then be added so the bees can deposit honey in the boxes. After the bees have started to build comb in the super containing comb-honey boxes, a second comb-honey super can be put on top. When the first comb-honey super is about half filled with honey, the two supers can be reversed (this usually increases honey production) and a third comb-honey super put on top in case the bees need more space. This can be repeated as long as the nectar flow continues, and as often as needed to give the bees more room in which to work without providing more sections than the nectar flow warrants. (If queen cells are present in such a colony they should be removed to prevent swarming; if the colony continues to produce queen cells it may indicate that the colony does not accept the queen. Therefore it may be necessary to kill the queen and introduce another queen.)

Supers full of comb-honey boxes should be removed as soon as the sections are completely filled and the cells are sealed. Near the end of the nectar flow the comb-honey supers should be removed in time to permit the colony to store enough honey in the hive for winter. Comb boxes full of honey should be separated into groups by weight and appearance and the weight and grade of each section must be stamped on top. The boxes should then be individually wrapped in plastic wrappers and sealed against dust and insects (plastic wrappings are available from bee-supply houses). Comb honey is graded according to weight, condition of cell-caps, cleanliness and fullness of combs. Federal standards divide the grades into U. S. Fancy, U. S. No. 1, and U. S. No. 2. Descriptions of these grades are available from the United States Department of Agriculture. (See references under "Honey and Beeswax" page 51.)

Producing crystallized (cream or granulated) honey. Beekeepers having only a few colonies can produce this attractive honey if they have an adequate supply of good extracted honey. A small investment may be required to purchase mixing equipment.

Heat extracted honey to be creamed to 160 to 175° F. to destroy yeast that may cause fermentation. This should be done in a water bath to avoid overheating. Cool the honey to 75 or 85°F., then add crystallized honey in the ratio of 10 to 20 per cent—for example, if 10 pounds of extracted honey are to be creamed, add 1 to 2 pounds of crystallized honey at this point, stirring carefully so that no air is mixed in. Pour honey into containers down a glass rod (or other solid surface) to eliminate bubbles of air in the honey. Store at 54 to 60°F.; the honey should cream in a week.

Creamed honey will become watery and less attractive if kept for long periods at room temperature (about 70°F) and if it is watery for too long it will ferment. The most favorable temperature for starting the crystallization of honey is 41 to 45°F. Storing creamed honey at about 40°F. will maintain it as an attractive food. If honey granulates (turns sugary) it can be liquefied by heating it in a container placed in 140 to 150°F. water.

Types of honey. Honey is classified according to floral source, method of production, and U.S.D.A. grades. The two most popular floral honeys produced in California are sage honeys and orange honey. Other major floral sources are: cotton, lima beans, alfalfa, yellow starthistle, wild buckwheat (of the genus *Eriogonum),* manzanita, eucalyptus, and bluecurls. In recent years safflower honey has been produced in quantity.

Honeydew honey, which is not a true honey, is usually made from a sweet liquid excreted by scale insects and plant lice or aphids. In California, one kind of honeydew honey is derived from a scale insect on incense cedar. Another honeydew honey in California is derived from galls on valley oaks; these galls produce a sugary material on their exterior that is collected by honey bees and stored in the same manner as honey. Major honeydew honey crops have been recorded from valley oaks in the foothills on the west side of the Sacramento Valley for 50 years.

Honey standards. Honey sold in California must meet certain standards as defined in the Agricultural Code (obtainable from State Department of Agriculture, Bureau of Fruit and Vegetable Standardization, Sacramento 95814).

Color is important in determining the market value of honey—lighter colors usually bring higher prices. Color varies from nearly colorless through shades of yellow, amber, and brown with greenish tinges, to deep red. Honey from the same floral sources may vary in color, and variation in color may result from overheating in processing — for example, honeys darken if heated too much or too long. Color is measured by the Pfund grader or the U.S.D.A. Color Comparator. These graders tell beekeepers the commercial color classification of honey: water white, extra white, white, extra light amber, light amber, amber, or dark.

HONEY MARKETING

The beekeeper can sell his honey from a roadside stand, from his home, directly to a retailer, to a wholesaler in 5-gallon cans or 55 gallon drums, or through a co-op. Cooperative marketing offers certain advantages to beekeepers because a cooperative can control a larger proportion of the total crop and thus increase members' chances for better prices.

Federal and state market programs. The U. S. Price Support Program includes a minimum base price for honey at the wholesale level. The support price varies from year to year. For information on this program, inquire at the county offices of the Agricultural Stabilization and Conservation Service (ASCS). The state marketing order for honey is administered by the California Director of Agriculture through the Honey Advisory Board, whose chief functions are research and promoting the use of honey.

PRODUCING BEESWAX

Beeswax is an important commodity used mainly by the cosmetics and candle-making industries. California produces approximately 600,000 pounds yearly—about 10 per cent of the total produced in the U. S. (the U. S. imports more beeswax than it produces).

Beeswax, which is secreted by wax glands located on the underside of the bee's abdomen, is used by the bees to construct combs. For maximum beeswax production, large quantities of honey must be present in the colony—bees have to consume 10 pounds of honey to produce 1

pound of wax. In preparation for wax production the bees gorge themselves with honey and hang in chains in the hive; about 24 hours after they do this, wax secretion begins.

Rendering beeswax. For small operations the solar wax extractor is the simplest and most economical way of rendering wax. Commercial beekeepers use steam-heated tinned copper, galvanized iron, aluminum, or stainless-steel containers for rendering—they may also use a heated wax press to render wax that would otherwise adhere to the cocoons in brood combs. (For more information on beeswax processing, see R. A. Grout, C. S. Bisson, or W. T. Kelly references listed under "Honey and Beeswax," page 51.)

Some beekeeper-supply dealers will buy raw wax, or will exchange it for foundation. Wax from comb-cappings yields the higher market prices.

ROYAL JELLY PRODUCTION

Royal jelly can be produced the year around in some areas in California. Good production requires the strongest colony that can be produced, adequate nectar and pollen flow, and feeding of colonies when natural sources of food are lacking. A queenright colony is usually used in royal jelly production, because queenless colonies require more labor to keep colony population high. For best production, any one of three types of hive set-ups is preferred.

Hive set-ups for royal jelly production

A 1-story hive with nine frames usually is used. This must be divided so that there are five frames for brood rearing and four frames for royal jelly production. To do so, a sheet of insect-screen wire and a sheet of plastic are fastened to a piece of wood so that the wood is between them. Screen and plastic should each be long enough to extend the length of the hive body inside. The screen should be wide enough to cover the side of a frame, and the plastic should be wide enough to cover the top bars of five frames. The long side of the screen and the plastic should be fastened to the wood, which should be ⅛-inch thick, 1-inch wide, and as long as the long side of screen and plastic.

The screen is placed between the fifth and sixth frame, and the plastic sheet is laid over the five frames where the queen is to be placed—this keeps her from moving to the adjacent four frames where royal jelly is to be produced. The four frames on the royal jelly side consist of two outer frames of honey and pollen, one inner frame with uncapped (open) brood, and another inner frame containing a bar with 15 to 20 regular cells which have been grafted with larvae (see grafting instructions, page 22). The nurse bees of the colony will be stimulated to secrete royal jelly to feed the larvae in the cells as well as the uncapped brood in the adjacent frame. The frame holding the grafted cells should be removed on the fourth day after it is placed in position. The cells are then trimmed down to the level of the royal jelly they contain and the larvae removed. After this a vacuum is used to remove the royal jelly from the cells. The jelly is packaged in 1-pound, air-tight Opalite ointment jars and refrigerated at 40°F. Usually, jelly is shipped to the buyer as soon as possible after harvest and by the fastest transportation possible.

Another set-up consists of a 2-story hive, with the 1-story set-up used as the second story (or super) above an excluder; each story should have its own queen.

The third hive set-up consists of a 2-story hive with the queen and colony of bees in the hive body, which is separated from the super by a queen excluder. A wooden rectangle (made of 1 inch stock) with outside dimensions equal those of the hive body and the super is placed over the queen excluder and the super is placed on it. This holds the bottom of the frames in the super an extra inch above the top bars of the frames in the hive body, and thus reduces the probability of crushing bees when frames are placed in

the super. Nine frames are used in the super. The center frame has a bar with 15 to 20 grafted cells on it for jelly production. On each side of this frame is a frame of uncapped brood. The other six frames are for honey and pollen.

Regardless of the set-up used, the colony must be managed in certain ways for maximum production:

• Frames of open brood on either side of the frame holding the bar of grafted cells must be replaced with new frames full of open brood at least every 14 days, or after every fourth graft, to get new brood, frames with empty brood cells are placed in the brood area in the queen-right portion of the hive.

• A residue of jelly is left in each cell when the jelly is harvested. A drop of one-half jelly and one-half water mixed is placed on the residue of jelly in the cell before grafting because the larva is more easily placed onto this drop. A grafting needle (see photo, top of page 23) is used for grafting; various designs are obtainable.

• The royal jelly producing cells should be grafted again as soon as possible after jelly has been harvested.

• Grafting larvae are obtained from frames of brood taken from royal jelly producing colonies.

• The queen sometimes cannot produce enough nurse bees, but this can be corrected by requeening for a more prolific queen. Additional bees can be added by placing combs of emerging bees from other colonies into weak colonies.

• Each colony should be harvested every fourth day; 1 pound of royal jelly per 200 colonies is usually produced under the best conditions. The best conditions for royal jelly production are the same as those for honey production.

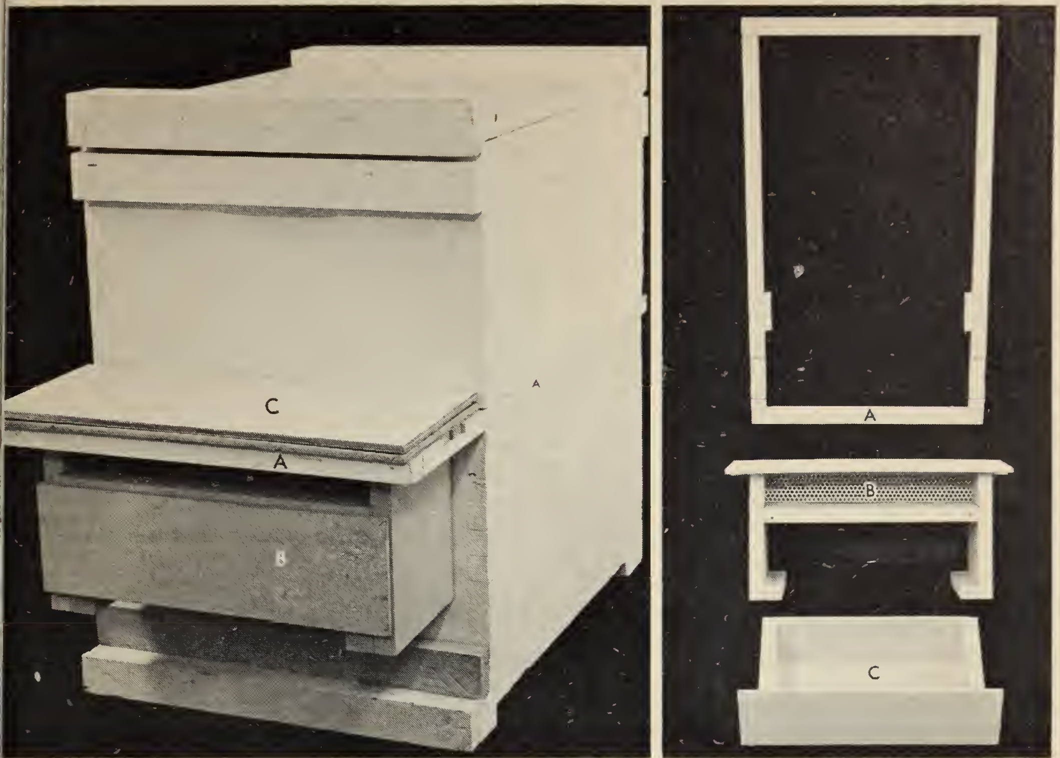
For best quality, jelly should be shipped as quickly as possible after production.

POLLEN HARVESTING

Pollen, a by-product of honey bee colonies, is used commercially as food for bees and other animals, for research on allergenics, and for use in helping evaluate the efficiency of colonies used for pollination services. Only pollen from disease-free colonies should be used for these, and pollen from plants toxic to bees (such as California buckeye) or pollen likely to be contaminated with pesticides should also not be used.

Pollen is carried to the hive in ball-like masses on the hind legs of foraging bees, and so it is harvested by placing traps at the hive entrance. These traps can be purchased, but beekeepers usually make their own. The main features of traps are a cover, a pollen-trap screen, and a collection tray with a bee-screen over it. The pollen-trap screen (which should be removed for a while every few days to give the colony a chance to store pollen in the hive) can be made from perforated metal strips with holes about 5 mm in diameter, or from two layers of 5-mesh hardware cloth separated by about a quarter of an inch. The double layers of hardware cloth should be offset so that the holes do not line up and the bees have to wriggle through; this increases the chance that pollen pellets will be knocked loose from their hind legs. The collection tray should be large enough to hold 2 or more days harvest, and its bottom can be cloth to allow air circulation and to reduce moisture in the pollen pellets. The entire trap should be covered to protect the contents of the collection from rain. The screen over the collection tray should have apertures small enough to prevent bees from entering the tray but large enough to allow pollen to drop through easily. A 6- or 7-mesh hardware cloth is best, but 8-mesh with thin-diameter wire may suffice and is easier to obtain.

Pollen should be trapped principally during good pollen flows. Pollen from the traps should be harvested at least every 2 to 3 days, and should be immediately stored at about 0°F.



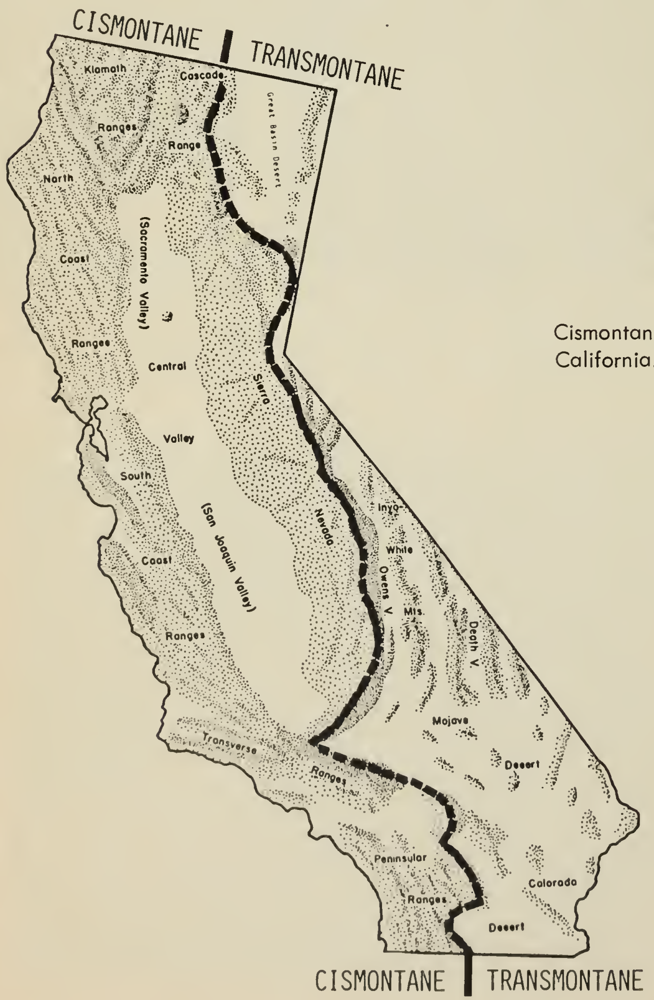
Left: pollen trap on beehive. **A:** trap-supporting board; **B:** pollen collection tray; **C:** trap cover. **Right:** details of trap. **A:** supporting board; **B:** pollen-trapping screen: as bees pass through this screen, pollen scraped off them falls through a screen below into collection tray **C.**

Worker honeybee gathering pollen from an almond flower.

SOURCES OF POLLEN AND NECTAR

Hundreds of species of California plants yield pollen or nectar, but the most important plants for commercial nectar are alfalfa, oranges, cotton, beans, sages (black, sonoma, white and white leaf), yellow starthistle, wild buckwheats, manzanita, eucalyptus, and bluecurls. Extensive use of herbicides to control yellow starthistle has decidedly reduced its pasturage in California. Alfalfa, oranges, cotton, and beans present a hazard for bees because of pesticides used on them.

California buckeye, *Aesculus californica* (Spach) Nutt., deserves a special note of caution because of its toxic nature to bees and its wide distribution and abundance. The tree is found throughout the foothills of cismontane (see "Glossary") California from Siskiyou and Shasta counties to Kern County and northern Los Angeles County below 4,000 feet. It blooms in May and June and is very attractive to honeybees, but bees feeding on its pollen are believed to produce larval food (pollen and honey) which results in malformed adults.



Cismontane and transmontane regions of California.

WILD PLANT SOURCES OF BOTH POLLEN AND NECTAR*

Plant	Where found	Time of bloom	Color of honey
Bluecurls (*Trichostema lanceolatum* Benth.)	Dry open fields, below 3500 feet; most of cismontane California.	August to October	White
Buckwheats, Wild (*Eriogonum* spp.)	Throughout California	April to November	Light amber
Buttonbush (*Cephalanthus occidentalis* L.)	Along streams and lake shores, below 3000 feet; throughout Central Valley and adjacent foothills.	June to September	White to light
Clover, Brewer (*Trifolium breweri* Wats.)	Wooded slopes below 6500 feet; in Sierra Nevada from Madera County north; Trinity, Siskiyou, and Del Norte counties.	May to August	White
Deervetch: broom; wild alfalfa (*Lotus scoparius* [Nutt.] Ottley)	Dry slopes, often following burns below 5000 feet; most of cismontane California.	March to August	White
Eucalyptus (*Eucalyptus* spp.)	Central Valley and Coast Ranges south to San Diego County.	December to July	Light amber
Filaree (*Erodium* spp.)	Stock forage plant of open grassy areas, below 3500 feet; throughout cismontane California.	February to August	Light amber
Goldenweed fleece (*Haplopappus arborescens* [Gray] Hall)	Dry foothills below 4000 feet (to 9000 feet in Sierra Nevada); cismontane Sierra from Nevada County to Tulare County; Coast Ranges from Del Norte County to Ventura County.	August to November	Amber

* See *California Flora*, Munz and Keck, 1959. Berkeley: University of California Press.

Wild Plant Sources of Both Pollen and Nectar (continued)

Plant	Where found	Time of bloom	Color of honey
Jackass clover (*Wislizenia refracta* Engelm.)	Alkali plains in San Joaquin Valley. Limited distribution due to land reclamation.	April to November	Water white
Mesquite (*Prosopis glandulosa* Torr. var. *torreyana* [L. Benson] M. C. Jtn.)	Washes below 3000 feet; Colorado and Mojave deserts, San Joaquin Valley and interior valleys from Santa Barbara County to San Diego County.	April to June	Light amber
Mountain misery (*Chamaebatia foliolosa* Benth.)	Open forest, 2000 to 7000 feet; Shasta County to Kern County.	May to July	Amber
Mustard (*Brassica* spp.)	Weeds of orchards, open grassy slopes, and waste places; throughout cismontane California. Limited by weed control.	January to May	Light amber
Poison oak (*Rhus diversiloba* T. & G.)	Low places, thickets and wooded slopes, below 5000 feet; throughout cismontane California.	April to May	White
Rabbit brush (*Chrysothamnus nauseosus* [Pall.] Britt.)	Dry, open plains and mountain sides, 2500 to 9500 feet. Mostly in transmontane California.	September to October	Light amber

Wild Plant Sources of Both Pollen and Nectar (continued)

Plant	Where found	Time of bloom	Color of honey
Sage, Black (*Salvia mellifera* Greene)	Dry slopes, below 2000 feet; Coast Ranges from Monterey Bay to San Diego County.	April to July	Water white
Sage, Sonoma [creeping] (*Salvia sonomensis* Greene)	Dry slopes, below 6500 feet; foothills of Sierra Nevada from Shasta County to Calaveras County, and Coast Ranges from Siskiyou County to Napa County, plus Monterey, San Luis Obispo and San Diego counties.	May to June	White
Sage, White (*Salvia apiana* Jeps.)	Dry slopes, below 5000 feet; Santa Barbara County south to San Diego County	April to July	Water white
Sage, White leaf [Purple] (*Salvia leucophylla* Greene)	Dry slopes below 2000 feet; Orange County north to Monterey and Kern counties.	May to July	Water white
Sages other than black, sonoma, and white leaf (*Salvia* spp.)	Mountain ranges and foothills throughout California, mostly below 5000 feet.	Spring and Summer	Water white
Spikeweed and tarweed (*Hemizonia* spp.)	Dry, open slopes and grassy fields, below 3000 feet; throughout cismontane California	April to November	Light amber to amber

Wild Plant Sources of Both Pollen and Nectar (concluded)

Plant	Where found	Time of bloom	Color of honey
Starthistle, Yellow (*Centaurea solstitialis* L.)	Widely distributed weed. Limited by extensive weed control program. Was widely spread in Sacramento Valley.	May to October	White to extra light amber
Sumac, Laurel (*Rhus laurina* Nutt.)	Dry slopes, below 3000 feet; cismontane southern California from Santa Barbara County to San Diego County	June to July	Amber
Toyon (*Heteromeles arbutifolia* M. Roem.)	Brushy slopes and canyons below 4000 feet; foothills and mountains of cismontane California.	June to July	Amber
Wild lilac (*Ceanothus* spp.)	Dry slopes, often rocky or wooded, mostly below 6000 feet; foothills and mountains of cismontane California.	March to July	White
Willow (*Salix* spp.)	Stream banks, meadows and wet places; throughout California.	January to July	Amber

DISEASES

Bee diseases are divided into two groups: those which affect the brood, and those which affect adult bees. Brood diseases generally are the more serious of the two. No disease of bees affects man.

Before attempting to diagnose disease, the beekeeper should become familiar with the appearance of healthy brood in all stages. In healthy colonies there is regularity in the arrangement of eggs, unsealed larvae, capped brood, and emerging bees. Healthy larvae in open cells are plump, glistening, and pearly white. Brood cappings normally are uniform and raised slightly above the comb surface. Once in place over the larvae, the cappings remain free of visible holes until emerging bees cut their way out of the cells.

Brood diseases

Symptoms of brood disease generally first become noticeable in combs containing mature brood where young bees are emerging, or in combs containing more than one cycle of brood. Symptoms also may be found in brood combs of the hive in which a colony has died of a brood disease.

A comb being examined should be so inclined that direct sunlight illuminates

the lower side walls and bottoms of the cells. This makes it possible to see any disease "scale" which might be present. If no dead brood is found in open or uncapped cells, it is advisable to remove any sunken, discolored, or punctured cappings and examine the cell contents. When dead brood is found, the following should be noted: position of dead brood, age and type of brood affected, color, consistency, odor of dead brood in various stages of decay, and position and tightness of scales.

The consistency of decaying larvae is important in disease diagnosis. Consistency can be determined by stirring the larger end of a toothpick into a decaying larva and slowly withdrawing the adhering mass, observing the texture and noting whether the material can be drawn out into a fine thread. This thread-like property is termed "ropiness."

Brood diseases most likely to be encountered

American foulbrood (AFB). This, the most serious bee disease in North America, is found in California, and at times has made commercial beekeeping unprofitable in some areas. Colonies should be inspected periodically for this disease.

Larvae dead of AFB lie fully outstretched on the lower cell walls. Pupae also may be killed and usually die with their "tongues" stretched across the cells. Diseased larvae or pupae gradually change color from white to dark coffee brown, and finally dry to become thin scales tightly adhering to lower cell walls. Decaying brood is slimy and ropy; the odor is mildly putrid.

American foulbrood is caused by a bacterium, *Bacillus larvae* White. Spores enter the bee larva in contaminated food, and bacteria resulting from these spores multiply and produce a toxin which kills the larvae in its cell, usually just after the cell has been sealed. The bacteria continue to multiply in the dead tissues and cause decay. As the decaying mass dries, the bacteria form into highly infectious spores, billions of which may be contained in a single dried scale. Spores of *B. larvae* are extremely resistant to high and low temperatures, to chemical disinfectants, and to the dehydrating action of honey which normally kills bacteria. The spores can remain alive and infectious for years in honey, in combs, and on used equipment.

AFB is spread within the colony by adult bees whose mouthparts are contaminated from working nectar or honey containing spores, or from attempts to remove diseased brood. Disease may be spread through larval food which has been secreted by bees having contaminated mouthparts. Nectar and honey become contaminated by being stored in cells containing diseased scale.

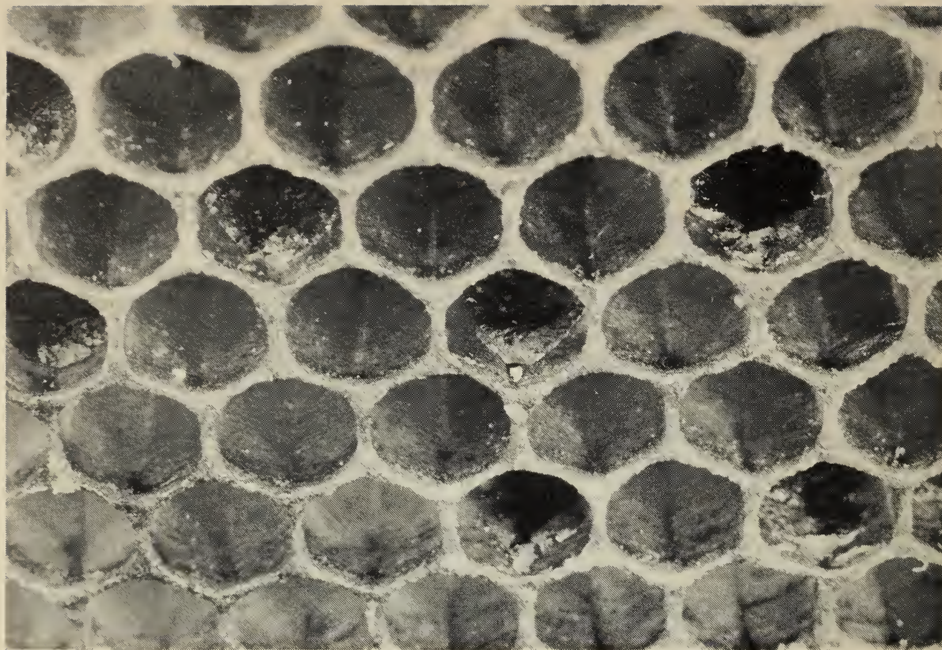
AFB is persistent, and infected colonies soon become unable to rear enough healthy brood to maintain colony population. As infection progresses, honey and combs in a diseased colony become heavily contaminated with spores, and the disease is spread to neighboring colonies if they rob the disease-weakened colony. Thus, diseased colonies constitute a serious menace in any area where bees are kept.

To control AFB and prevent its spread, colonies must be inspected regularly and diseased colonies must be destroyed. After the disease has been discovered in an apiary the remaining colonies should again be thoroughly examined in 30 to 60 days. A beekeeper not experienced in AFB abatement who finds signs of this disease in his apiary should immediately contact his County Agricultural Commissioner to obtain assistance.

Drugs may be fed to colonies *not* showing AFB disease symptoms as an aid in preventing the disease. Sodium sulfathiazole and Terramycin® are registered for such use and have appropriate directions on the container label. It is unlawful in California to treat or otherwise maintain an AFB-diseased colony of bees.

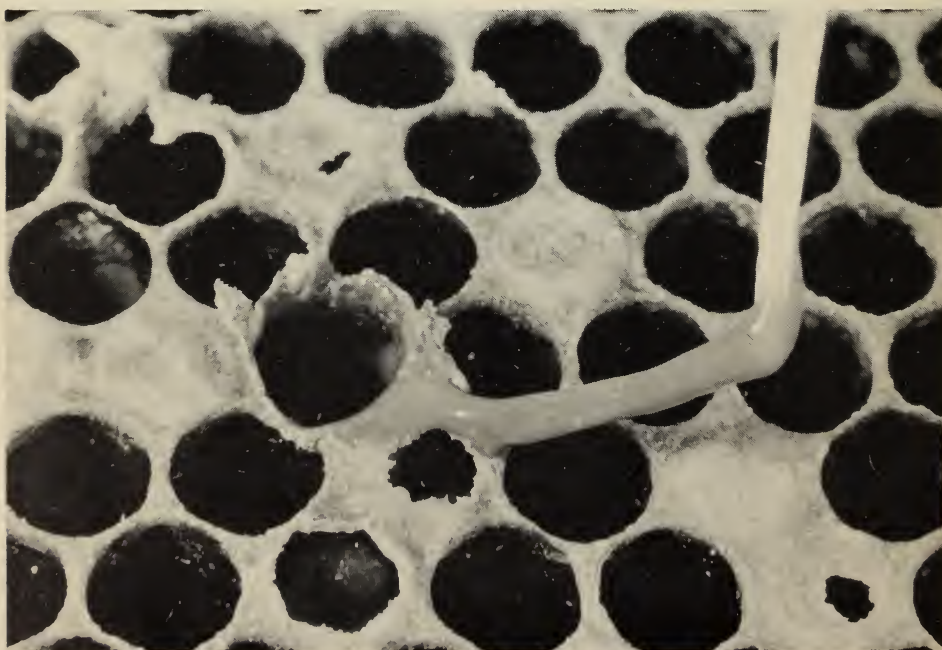
European foulbrood (EFB). This disease, which occurs in some parts of California, can seriously cripple a colony. Strong colonies usually recover.

Larvae dead of EFB are coiled in the cell bottoms, or twisted across the lower cell walls; occasionally, they die in an outstretched position. Diseased larvae first turn yellow, then brown, and finally



Dried remains (scale) of American foulbrood diseased larvae in bottom of cells.

Ropiness test for American foulbrood. Larvae killed by this disease are slimy and ropy.



dry to form dark, irregularly-shaped scales which are easily removed from the cells. Decaying larvae have a wet, paste-like consistency, sometimes exhibit a degree of ropiness and dry to form scales closely resembling those of AFB disease, and give off a sour odor. Pupae rarely are affected. Rarely, a larva dead with EFB is found with the head upstretched to resemble the tongue mentioned in the discussion of American foulbrood.

Sometimes EFB disease appears suddenly and spreads rapidly through colonies—this is most likely to occur in spring after the first or second brood cycle. At other times, it may spread slowly and do little damage. A good nectar flow seems to hasten recovery. The disease usually subsides by midsummer, but occasionally remains active during summer and fall; or it may seem to disappear and then reappear in the fall. Terramycin is registered for use in treating EFB-diseased colonies. Sulfa is not effective. Label directions must be followed closely to avoid injury to brood or contamination of honey.

The disease usually can be controlled by dequeening the diseased colony for 10 days to break the brood-rearing cycle and to give the bees an opportunity to clean diseased brood from the cells. The colony can then be requeened and more bees added, or it can be united with a stronger colony after the 10-day period. This treatment is also effective against parafoulbrood.

Parafoulbrood. Parafoulbrood is occasionally found in California and is comparable to EFB in its effect. Larvae dead with parafoulbrood typically lie twisted across the lower cell walls, although sometimes those lying in a normal coiled position may also be dead. Occasionally older larvae in sealed cells are killed and lie outstretched. The decaying mass has a reddish-brown color, and the texture usually is moist and pasty, or gummy; occasionally there is ropiness. This disease is easily confused with either AFB or EFB and sometimes appears to be a mixture of the two.

Sacbrood. Sacbrood seldom results in more than slight damage to colonies. Larvae killed by the disease lie fully outstretched on the lower cell walls, and are usually gray or brown and darker at the head end. The larval skin remains intact, and the body contents become watery, making it possible to remove diseased larvae intact as a fluid-filled sac. The odor is sour. Scales are brown and wrinkled, and they are easily removed. Sacbrood is more prevalent in spring but usually clears up with a good nectar flow. Colonies in which the disease persists can be requeened with resistant stock, or united with stronger colonies after killing the susceptible queen.

Adult bee diseases

There are two major diseases of adult bees—nosema and paralysis. The first signs of these are an abnormal number of dead or dying bees at the entrance of a colony, or the presence of crawling or paralyzed bees.

Nosema. This disease, which is caused by a minute parasite, seldom causes noticeable loss in California. The only reliable way to determine if nosema is present in a colony is to submit a sample of bees for laboratory examination. It usually occurs in bad weather when bees are confined to hives. An infected colony may become seriously weakened during the critical population buildup in spring. Infected bees may have their lives shortened as much as 40 per cent, even though they appear to forage normally until shortly before death. Just before dying the bees become greatly distressed and are unable to fly; such bees may be found crawling about on the ground near an affected colony making unsuccessful attempts to fly. They sometimes drag their legs, and their wings may seem to be dislocated. Their bodies often appear shiny and greasy, with the abdomen distended; dysentery symptoms may be present. Dying bees may stay in one place and tremble.

Loss from nosema is not always immediately apparent, as it is common for infected bees to die away from the hive. It usually is too late to apply effective control when signs of the disease are seen, so prevention is the only control. (Fumidil-B® is registered as an aid in preven-

tion.) The disease can best be prevented by keeping colonies strong, and by overwintering them in locations sheltered from wind and open to maximum sunshine. Confinement of bees, pollen shortage, queenlessness, chilling, and frequent handling can cause rapid buildup of nosema.

Paralysis. Paralysis disease is widely distributed in California. It seldom causes serious damage, except occasionally in southern California, and affected colonies usually recover.

Diseased bees may be seen on top bars, or at the colony entrance. Typically, they are weak, they shiver or tremble and are unable to fly or walk in a coordinated manner. Frequently their legs are widely sprawled, their wings disconnected, and their bodies hairless, with a dark greasy appearance. They have a distinct and repulsive odor.

Paralysis is mildy infectious, being transmitted directly from sick to healthy bees. Colonies in which the disease seems to persist can be requeened with resistant stock.

BEE DISORDERS

Healthy colonies do not tolerate the presence of dead brood and will remove it as quickly as possible. Seriously weakened colonies should be strengthened or united with stronger colonies to hasten removal of dead brood from the combs.

Chilled or starved brood. Chilling usually occurs in early spring when a severe drop in temperature follows warm weather—this causes the bee cluster in the hive to contract and to neglect feeding brood in outer portions of the brood-rearing area. Chilling can also result from separating brood combs from the main brood areas, or from neglect if too many bees are lost to pesticides or other causes. Brood dead from chilling or starvation will be found in a clearly defined area, not scattered among healthy brood. All stages of brood in the affected area will be dead. Dead brood is gray or brown, and has a slightly sour odor; it is easily removed from cells. Symptoms usually disappear with warmer weather, during feeding, or with the beginning of a nectar flow.

Overheated brood. Brood dead from overheating resembles brood dead from chilling or starvation. When such brood is found at the same time that older larvae

DIAGNOSING DISEASES

If there appears to be a mixture of symptoms, or if symptoms do not appear typical, it is advisable to submit samples to: Apiary Inspection, California Department of Agriculture, 1220 N Street, Sacramento, California 95814. Diagnosis is free.

To take samples of diseased brood, a smear should be made by stirring the cell contents with a clean toothpick. Transfer the smear to a small piece of paper along with the toothpick, fold the paper to prevent contamination, and place into an envelope along with a letter requesting diagnosis. Samples of scale pried loose from cell walls may be submitted in the same manner.

Samples of adult dead bees should be fresh; dried specimens are of little value. Samples should be carefully selected and made up of bees which appear to be affected. They should be mailed in a container that will protect them from crushing. Live bees may also be sent provided they are properly caged. Satisfactory diagnosis can be made from a sample of 10 to 20 bees.

Comb samples are difficult to handle and are unnecessary in laboratory diagnosis for AFB determination.

are observed outside their cells, overheating has occurred. To prevent this bees should have adequate ventilation, an ample supply of water, and shade.

Dead drone-brood in worker cells. If a queen bee lacks sperm, she will lay only drone-producing (unfertilized) eggs. If no queen is present worker bees will sometimes lay eggs, but these will be unfertilized. This drone brood, which occurs in irregular patches with dome-like caps, is often allowed to die. It may be found in various stages of decay, usually in moist, pasty, brown patches having a sweet-rotten odor.

Queenless colony. A colony without brood during the active season usually is queenless. Queenless colonies usually show greater disturbance when the hive is opened. Scattered cells of pollen with a glossy appearance found in the area normally occupied by brood are typical of a queenless colony.

Dysentery. This is a functional disorder which may result from eating indigestible food during a prolonged period of confinement. The most noticeable sign of dysentery is fecal matter in the hive, as bees normally void their body wastes while in flight outside the hive. Honeydew, unripened honey, or overheated honeys are unsuitable as feed if bees are unable to make frequent flights to void body waste (as is common in winter).

Starvation. Starvation is the major cause of colony loss in winter and spring. Conclusive proof of starvation is the presence of clusters of dead bees head first in comb cells where they have died in search of food. Often, colonies which have produced a large amount of early brood deplete their stores and die of starvation during confining weather in spring. Colonies also may starve later in the season if subjected to a prolonged dearth between nectar flows.

The most obvious sign of approaching starvation is loss of hive weight, or absence of sealed honey during a nectar dearth. Starving bees are restless and crawl slowly about the comb as though cold even though the weather may be warm. Egg-laying is retarded or ceases entirely, and brood is neglected and allowed to die. Cappings sometimes are removed and the brood eaten. Starving bees occasionally cluster in a "hunger" swarm, usually on or near the hive.

POISONING

◀ Bees killed by pesticides.

The first sign of poisoning usually is the appearance of a large number of dead or dying bees at colony entrances throughout the apiary. A knowledge of local pesticide programs, and of blooming plants which may be toxic to bees, is important in avoiding poisoning.

Pesticide injury. Most pesticides kill larvae in all stages as well as adult bees. Pesticide dusts are particularly hazardous because of their greater tendency to drift. If pesticide damage is suspected, the beekeeper should immediately file a report of loss with the Agricultural Commissioner of the county in which the damage occurred so the loss can be properly recorded and investigated. Beekeepers can request the Commissioner's Office to no-

tify them when pesticides they consider particularly dangerous to their colonies are going to be applied in their area—they will be given a 48-hour warning. A list of pesticides showing their relative toxicity to bees can be obtained at any Farm Advisor's office.

Poisonous plants. California plants producing nectar or pollen poisoncus to bees are: California buckeye (*Aesculus califorina* [Spach] Nutt.), Deathcamas (*Zigadenus venenosus*), Cornlily (*Veratrum californicum*), and locoweed (*Astragalus* spp.). Because of its wide distribution, buckeye is the most hazardous to bees.

Symptoms of buckeye poisoning usually appear about a week after bees begin working the blossoms. Many young larvae die, giving the brood pattern an irregular appearance. The queen's egg-laying rate decreases or stops, or she may lay only drone eggs; after a few weeks an increasing number of the eggs fail to hatch, or a majority of the young larvae die before they are 3 days old. Some adults emerge with crippled wings or malformed legs and bodies. Foraging bees feeding on buckeye blossoms may have dark, shiny bodies and paralysis-like symptoms. Affected colonies may be seriously weakened or may die. However, the queen may resume normal egg-laying if the colony is moved from the buckeye area.

Honey produced from California buckeye is not poisonous to humans. (Oddly enough, neither is honey produced from poison oak.)

BEE PESTS

Wax moths are widely distributed and their larvae can destroy a weak colony by burrowing through the cells and consuming the pollen and wax (strong colonies can protect themselves). Combs kept in storage are also liable to attack by the larvae but the combs can be fumigated to destroy moth larvae if they do not contain honey for human consumption. The simplest and safest fumigation procedure is to stack five supers of empty combs as tightly as possible on hive cover to prevent gas escaping from the bottom of the stack. Then put a piece of paper on the top bars of the top super and sprinkle 6 tablespoons of paradichlorobenzene (moth crystals) on the paper. Put a hive cover tightly in place on top of the paper. For long storage (as in overwinter) seal joints with masking tape and add more moth crystals every 2 to 3 weeks if no crystals are present. After fumigation, air the combs for a few hours before using.

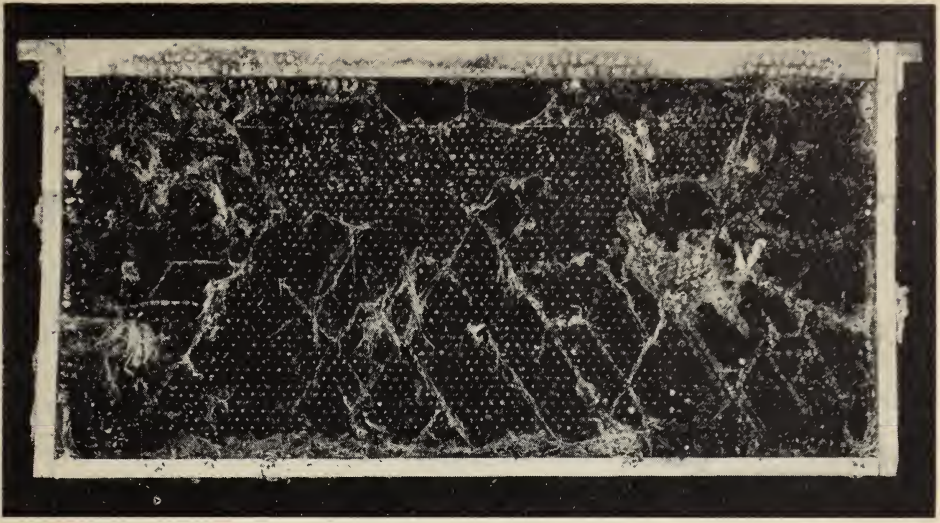
Ethylene dibromide (EDB), a liquid which slowly fumes on contact with air, can also be used for fumigating. EDB is non-flammable but toxic. Avoid skin contact and do not breath fumes. Stack supers to be fumigated out-of-doors. Put aluminum foil cover over the top bars of the uppermost super, leaving 3 inches open space around edges, then place a folded paper towel or other absorbent material on top of the foil and put 1 tablespoon of EDB on this; edges of foil should be turned up to prevent EDB from running into comb. Place a hive cover over the top of the super. No more than eight full-depth supers should be treated in a stack. Fumigation should continue for at least 24 hours and should be repeated if inspection shows wax moth activity. If there are numerous supers, 1 pound of EDB per 1000 cubic feet should be used in a fairly airtight room; fumigate for 20 hours.

Bears have a natural fondness for brood as well as honey, and they may destroy hives in mountain locations (beekeepers in such areas should consult the local farm advisor about the problem).

Large livestock sometimes damage colonies located in the same field unless the apiary is fenced.

Skunks visit colonies at night to scratch the dirt in front of the hive (or at the entrance) and then eat bees that come out to investigate. Skunks molesting colonies can be trapped or poisoned.

Field mice can be destructive to combs in a hive during winter. An entrance guard of ⅜-inch-mesh hardware cloth pro-



Comb damaged by wax moth larvae. The thread-like material is webbing laid down by moth larvae.

vides effective protection against entry of mice in fall or winter.

Ants of various kinds, especially the Argentine ant, may invade hives. They can be controlled by insecticides applied to the ground surface before the bees are moved into the apiary, or the hives can be placed on stands made ant-proof by placing the legs of the stands in cans filled with oil.

Vandalism often is avoided by placing colonies in clear view of passers-by and by posting a notice to the effect that property molesters will be prosecuted. Some associations provide such posters for their members.

LAWS REGULATING BEEKEEPING

California bee laws, which are enforced by County Agricultural Commissioners, provide the basis for an effective apiary inspection program to help beekeepers protect honey bee colonies from disease, pesticide, and theft.

Excerpts from California Agricultural Code relating to bees and apiary inspection can be obtained from: Supply Service, California Department of Agriculture, 1220 N Street, Sacramento 95814. Beekeeping in some localities is also governed by city or county ordinances so beekeepers should consult local authorities about this.

Apiary registration. All apiaries must be registered each November 1 with the Agricultural Commissioner of the county in which the colonies are located. Registration is free and consists of listing the location of each apiary and the number of colonies at each location. Newly acquired apiaries, and apiaries brought into the state, must be registered within 30 days of establishment.

Apiary movements and identification. Details of laws pertaining to movement and identification of apiaries can be obtained from County Agricultural Commissioners. Beekeepers in Alpine, Inyo, Mariposa, Mono, and Trinity counties, which are without agricultural commissioners should send apiary registrations, movement notices, and inspection requests to: Supervisor of Apiary Inspection, California Department of Agriculture, 1220 N Street, Sacramento, California 95814.

AN OBSERVATION BEE HIVE

Few hobbies are as exciting and educational as keeping a colony of bees in an observation hive. The behavior of bees as a social unit, and their elaborate means of communication, can be used to illustrate basic biological concepts in teaching at all levels from kindergarten to college. Once the colony is established behind glass walls, anyone can visually enter the world of the honey bee to observe the activities of an intriguing society; all of the honey bees' life in the hive is unveiled, from egg laying by the queen to the emergence of new-born worker bees from cells in the comb. Some bees will be seen processing pollen into bee bread, others will be converting nectar into honey, and many other worker bee activities such as cleaning the nest, building comb, and exchanging food can be seen night and day. But perhaps the most fascinating sight is that of worker bees returning from foraging trips heavily laden with brightly colored pollen pellets as they enter the hive and perform dances that tell other workers where the pollen was gathered. (As an added bonus, bees in a 4-frame observation colony may produce up to 20 pounds of honey annually.)

To fully appreciate an observation hive, you should have some background knowledge about the biology and behavior of honey bees. Many excellent books on bees are available, and a few hours of reading some of these will pay great dividends (see reference section at end of text).

The hive itself should be located so as to permit observation from both sides. Access must be provided from the hive to the outdoors so that the bees can forage for food and water—a transparent runway through the wall or a window will provide for this. Ideally, there should be no sidewalks or parking areas within approximately 30 feet from the exit. Runways can be of considerable length and can be built to turn corners or curves, although bees seem to orient better if they can see light at the runway's exit.

Constructing and mounting the hive

Observation hives can be purchased, but the hive shown below is economical and simple to construct and will accommodate four standard full-super frames. Bees need this amount of space for clustering, rearing brood, and storing food reserves.

Ideally, the hive base should be mounted rigidly to a sturdy table or platform. Because all manipulations of the colony must be made outdoors, the mounting and runway attachments should be made in such a way that the hive can be easily disconnected. Before the bees are installed, temporarily mount the hive in its permanent position and then construct the runway to the outdoors. Runways can be made with parallel wooden strips on a wooden floor and covered with glass, Plexiglas, or plastic. Fibrous material such as cardboard, paper, or cloth should never be used; bees chew through these materials in a few days.

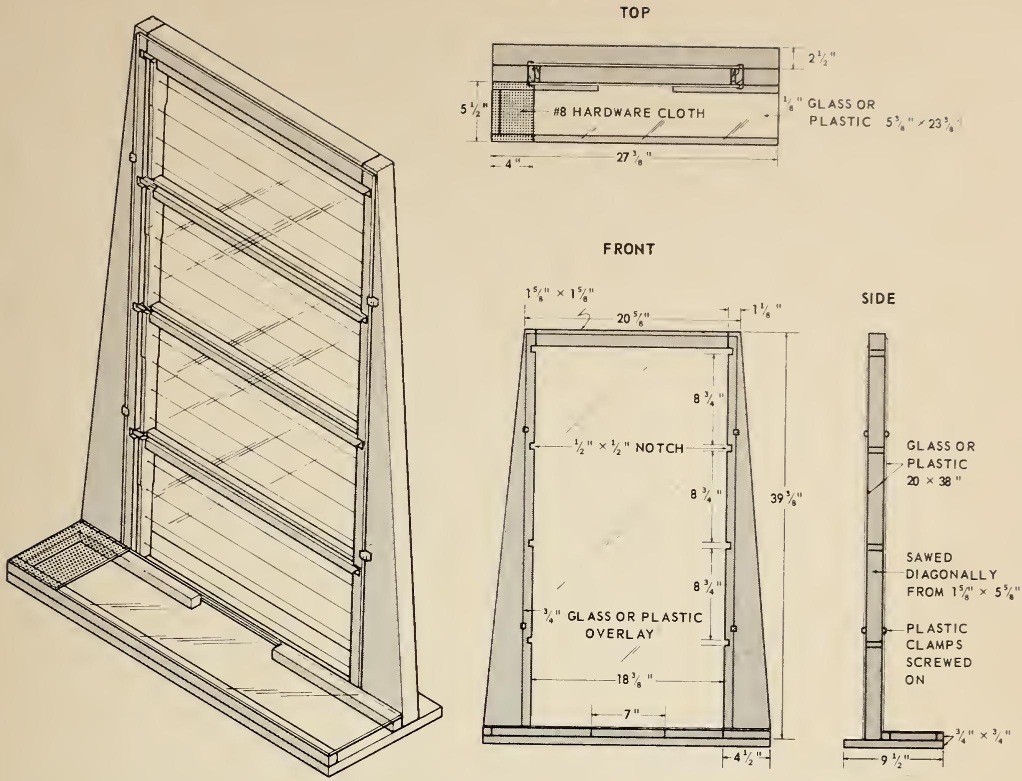
Sometimes there is a problem in making an opening through the window to accommodate the exit runway. One solution is to replace the window glass with a sheet of Plexiglas or plywood in which an opening can easily be cut. For an attractive installation, paint all wood parts (except the frames) of the hive and runway before the glass or plastic is mounted. White observation hives are most attractive, but any color is satisfactory. Paint should be dry before bees are placed in the hive.

Establishing the observation colony

Bees may be installed in the observation hive anytime between early spring and mid-summer. Worker bees may be purchased along with the queen; approximately 3 pounds of bees are sufficient.

The quickest method to establish an observation hive is to put frames of brood and a queen from a conventional hive into it. Once the queen is inside the observation hive, the temporarily disorganized bees (including those outside the hive) will soon find the queen and cluster around her.

Instead of purchasing packaged bees, a swarm may be captured and installed.



An observation hive, with construction details. Commercial observation hives are also available.

During the swarming season each spring various public agencies (police, fire department, county agricultural agencies) receive numerous requests to remove swarms, and they frequently are willing to place applicant's names on a "swarm waiting list."

Installing a swarm. Lay the observation hive (containing frames) on its side with the runway side up, propping the top of the hive on a box approximately 1-foot high. Loosen the plastic mounting clamps on the upper glass wall and slide the glass approximately 1 foot toward the hive top. Then shake the cluster of bees into the opening and gently slide the glass wall into position, being careful to avoid crushing bees. Inevitably, a few bees may not get into the hive, and these should be checked to see if the queen is among them. If the queen is among them, she should be captured and placed in the hive.

Installing packaged bees. Prepare the hive as in the instructions immediately above. Now, lightly sprinkle water on the wires of the package—this will calm the bees. Rap the package so that worker bees will fall to the bottom, and then remove the queen cage from the package. One end of the queen cage has a hole with a cork disk over it—remove this disk, exposing the "candy" beneath it. Place the cage inside the hive near the lower frame, making sure that the cage's screen can be reached by worker bees (who will have to feed the queen through the screen for a few days).

Now shake the bees into the hive and slide the glass wall shut. The bees will be attracted to the queen, and will eat the candy which blocks her exit from the queen cage, thus freeing her. If the cage is not supplied with candy, the queen should be released immediately. The empty cage can be removed when convenient.

Transferring bees from conventional hive to observation hive. Remove two

frames of capped brood, one frame of honey, and one frame of empty comb from a conventional hive (all frames should be covered with bees). Place them in that order, bottom to top, in the observation hive. Shake additional bees from the conventional colony into the observation hive. Make certain that the queen has been transferred.

Maintaining the observation hive

After the newly established hive is mounted, a feeder containing sugar syrup should be provided for the colony. Feeders can be made by punching or drilling 20 to 50 small holes in the lid of a pint or quart glass jar; the jar should then be filled with sugar syrup and inverted over the feeding chamber. Sugar syrup should be available continuously until all the combs are filled with honey or brood. Thereafter, the colony should be fed only when its stored honey is gone.

Under normal conditions established colonies are self-supporting and require little maintenance. However, colonies in observation hives require special maintenance because there are fewer foragers than in the regular hive. When weather conditions permit foraging flights, and nectar and pollen are available, the observation colony collects nectar rapidly and accumulates an abundance of honey —this reduces need for maintenance.

Preparing the colony for winter. Unless the climate permits bee flight at least once a month, it is not advisable to try to maintain an observation colony in winter. Without periodic flights, high mortality usually occurs, and the colony may die in mid-winter or early spring. Therefore, it is usually best to terminate the colony in autumn after brood rearing has ceased (the queen can be removed earlier if desired). This is done by shaking the bees off the observation hive frames near the entrance of a normal outdoor colony. The bees will soon be accepted into the colony. The frames of combs from the beeless hive may then be wrapped and stored at 0°F.; this prevents granulation of honey and infestation by pests during storage. The following spring a colony may be reestablished in the hive, using the stored frames of comb.

Special problems and their solutions

Although honey bees are largely self-sufficient, minor difficulties may arise occasionally. These are discussed below.

Sunlight. Observation hives should never be exposed to direct sunlight.

Ventilation. Normally, the observation hive will have adequate ventilation through its runway to the outside and additional ventilation ports will not be necessary. However, if the inside of the hive walls become fogged for a prolonged period, additional ventilation ports (¾ inch holes covered by 8-mesh wire screen) may be provided on the top or ends of the hives. Healthy colonies typically are full of bees, and it is a mistake to suppose that bees need additional ventilation simply because they appear to be crowded.

Swarming. In spring colonies increase rapidly in population, and swarming is therefore to be expected. The hobbyist may wish to study this phenomenon, but if he wishes to prevent it the easiest control method is to kill the old queen when the colony population reaches its peak in the spring (she can be killed by pinching her head). A new queen will be reared automatically by the bees, and the short interruption of brood rearing normally stops swarming tendencies for the remainder of the season.

Invasion by pests. In some areas ants are a serious pest of bees, and colonies invaded by ants are liable to become disorganized enough to stop their normal activities. Poisonous baits for ant control may be used near the colony, but access by bees (or other animals) to baits must be prevented by covering bait containers with 8-mesh wire screens which should be at least ½ inch from the bait itself so that bees cannot reach through and eat the bait. Do not use insecticides near the hive.

Population decline. Except for normal seasonal fluctuations, a decline in bee population usually is caused by insufficient brood rearing. Usually, the hive

population is stable: hundreds of new bees emerge each day and compensate for normal losses (bees live 6 to 8 weeks in summer, and up to 6 months in winter). If brood rearing decline is caused by an old and inferior queen, queen replacement is usually the best solution (see page 20).

Lack of food. The threat of starvation is greatest when rapid consumption of hive food supplies occurs during the intensive spring brood rearing. If the hive contains enough capped cells of honey, bees will not starve; if capped honey is not present, sugar syrup should be fed to the colony.

Accidental bee escapes. Because they are confused, bees accidentally released indoors usually do not sting. However, stinging may occur near the colony within a few seconds after bees escape, particularly if thousands are liberated suddenly. If this happens, permit the colony to settle a few minutes; after bees have settled down, the hive and any adhering bees may be gently taken outdoors. (Any bees remaining in the building may be easily caught with a vacuum cleaner). Whenever the colony is carried outdoors, always remember to plug up the runway at the point where it was disconnected from the hive.

Orientation of bees. Observation hive bees can become disorganized (disoriented) when they are installed, or after any change in the arrangement of the colony runway. Disoriented bees in a hive seem to be wandering about and do not perform any of the chores they usually do. Several days may be required for forager bees to adjust to a new location or runway arrangement. Young bees just learning to fly may be seen in intensive flight around the hive entrance in early afternoons; this is their method of orienting themselves to the colony in preparation for later foraging.

Use of smoker and protective clothing. To control bees a few gentle puffs of smoke should be blown into the hive entrance just before the top of the hive is removed. When smoke is applied skillfully and in small amounts the risk of being stung is minimized; however, one should always wear a bee veil and clothing that protects the entire body. Always move slowly and carefully around bees—fast motion, loud noises, or any jarring of the hives excites them.

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GLOSSARY

Abdomen: The section of the body behind the thorax containing the sting apparatus.

Acid board: A specially designed board used to drive bees off the honey comb so the honey can be harvested.

Apiary: A collection of populated bee hives.

Balling: Mass attack of worker bees on the queen.

Beeswax: A wax secreted by the wax glands located on the underside of four abdominal segments of the bee. It is used by the bees to construct comb.

Brood nest: The area inside the hive body devoted to brood rearing.

Burr comb: Comb on top bars of frames.

Cell: One of the hexagonal compartments of the honey comb in which the brood is reared or the food is stored.

Cismontane: Area west of Sierra Nevada Mountains in northern and central California, and area west of Mojave and Colorado deserts in southern California. (See also "transmontane.")

Cluster: A colony of bees clinging together for warmth.
Colony: A community of bees living in close association and contributing to their mutual support by their labor. It is composed of a queen and worker bees, and during spring and summer drone bees are present. The terms "colony" and "hive" are often used interchangeably.
Comb: A mass of hexagonal cells made of beeswax and containing brood and food. Bees build combs on foundations in frames.
Drawn comb: Comb constructed on a sheet of foundation.
Drone layer: A queen that lays only unfertilized eggs, which produce only drones.
Foundation: A thin sheet of beeswax imprinted with the hexagonal cell bases of the honey comb; used as base for comb when placed in frames.
Frame: A rectangle usually made of wood that is hung inside the hive; it supports the foundation and comb. Sometimes "frame" and "comb" are used interchangeably: a "comb of brood," a "frame of brood."
Head: That area of the bee's body bearing eyes, mouthparts, and antennae.
Hive: A container housing a colony of bees. Usually consists of a hive body below and a super above.
Hive body: The part of the hive containing frames of combs in which the queen lays eggs. The hive body rests on the bottom board.
Larva: The immature and worm-like form which develops from the egg.
Larvae: Plural of larva.
Meiosis: A process whereby the nucleus of the bee egg divides and leaves the mature egg ready for fertilization by the sperm with one chromosome set (16 chromosomes) in honey bees.
Nectar: A sweet liquid secreted by plants, mostly sucrose sugar and water.
Nucleus ("Nuc"): A small colony in a small hive used to mate queens, composed of worker bees only with an introduced queen.
Pollen: Male sex cells produced in anthers of flowers. They are powder-like and are composed of many grains. Gathered and used by honey bees for food—a source of protein.
Pollinator: An insect agent which pollinates flowers.
Pollination: To place pollen on the stigma of a flower. In beekeeping, refers to the service provided by honey bees in crop production.
Propolis: Plant resins collected by bees and used by the bees as a cement to stick hive parts together and to seal openings. Also called bee glue.
Pupa: The preadult form of bees occurring after the larval stage and maintained without evident change in size and structure until the adult bee emerges from the cell.
Queenright: A colony containing a queen.
Queenless: A colony without a queen.
Slumgum: That which remains after all the wax has been rendered from old comb; it consists mostly of pollen and brood cocoons.
Super: A wooden box with frames containing foundation or drawn comb in which honey and pollen are stored. The same type of box is referred to as a "hive body" when it contains brood as well as honey and pollen.
Supersedure: The replacement by the worker bees of an inferior queen bee by a new queen that they have produced.
Thorax: The middle area of the body of the honey bee. This part of the body bears the wings and six legs.
Transmontane: Area east of Sierra Nevada Mountains; includes Mojave and Colorado deserts.

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